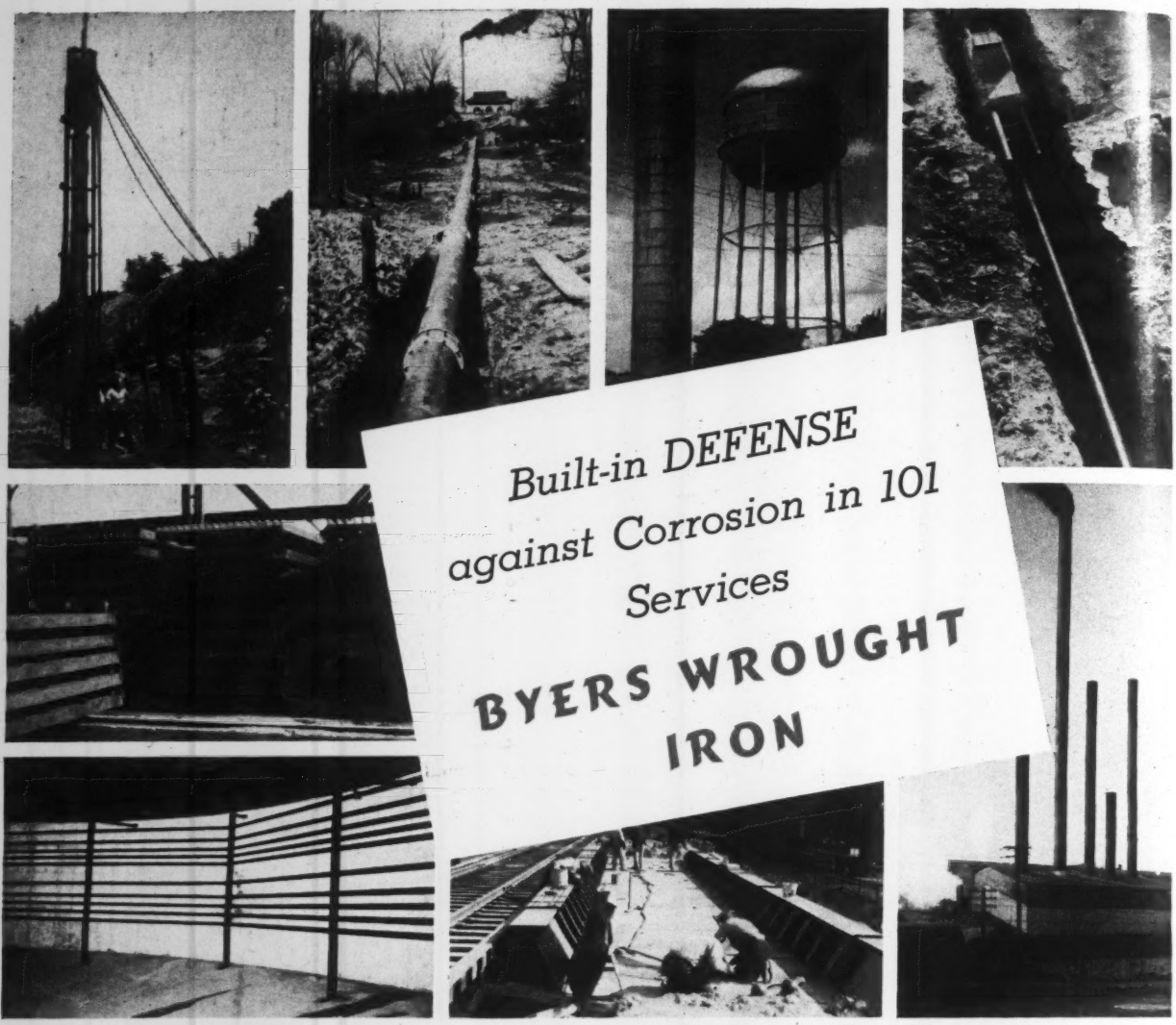
ENGINEERING NEWS-RECORD

UNIVERSITY OF MICHIGAN
GENERAL LIBRARY
ANN ARBOR MICH



Built-in DEFENSE against Corrosion in 101 Services

BYERS WROUGHT IRON

Because the only sure defense against the high cost of corrosion in heavy construction is the use of corrosion-resistant materials *from the very beginning*, more and more construction engineers are building with Byers Wrought Iron. The illustrations show only a small portion of the many services where Byers Wrought Iron is in use today, but they will suggest other applications for this durable material.

An installation of Byers Wrought Iron in a water well casing at Ambridge, Pa. suggests its use for well screens, downspouts, water mains and service lines. A sanitary sewer line at Cleveland, Ohio brings to mind industrial sewage lines, storm sewers and outfalls fabricated of Byers Wrought Iron. An elevated water tank exposed to the salt air at Rehoboth Beach is a reminder that almost every kind of tank imaginable is included in the list of those made of wrought iron. Conduit in a traffic control project in Essex County, N.J. is one of a group of installations in the electrical field that includes transformer tanks, conduit boxes, relay cabinets, and switch boxes.

Byers Wrought Iron trash racks for the Grand River Dam call to mind other river installations . . . protection plates for locks and piers, skin plates, and gates. Digester coils and racks in a sewage disposal plant at Marion, Ill. indicate the severity of services where Byers Wrought Iron is serving in sewage treatment plants. Deck plates in the Portsmouth, N.H.-Kittery, Me. Bridge are Byers Wrought Iron, as are blast plates, cover plates, deck drains, railings, and downspouts of bridges in many parts of the country. Smokestacks at Champaign, Ill. are among the scores of power plant installations of Byers Wrought Iron in breechings, smokeboxes and uptakes, bunkers, coal chutes, and spouts.

Perhaps there are services in your projects where ordinary materials do not last . . . or perhaps under such conditions you have been using special materials that you now find hard to obtain. If so, we urge that you consider the possibility of using Byers Wrought Iron—not only from the standpoint of durability, but availability. Many services where Byers Wrought Iron is serving are illustrated in the booklet, "101 Uses for Wrought Iron." Write for a copy.

A. M. Byers Co., Pittsburgh, Pa. Established 1864. Boston, New York, Philadelphia, Washington, Chicago, St. Louis, Houston, Seattle, San Francisco.

CORROSION COSTS YOU MORE THAN WROUGHT IRON

BYERS GENUINE WROUGHT IRON

TUBULAR AND FLAT ROLLED PRODUCTS

STEEL TUBULAR PRODUCTS

ENGINEERING NEWS-RECORD

Devoted to Buildings, Sewers, Waterworks, Bridges, Highways, Streets, Dams, Foundations, Earthwork, Flood Control, Public Works, Irrigation, Canals, Railroads

McGRAW-HILL PUBLISHING COMPANY, INC.

Publication Office: 99-129 North Broadway, Albany, N. Y. • Editorial and Executive Offices: 330 West 42nd Street, New York

JOHN ABBINK, *Publisher*

WALDO G. BOWMAN, *Editor* ALBERT E. PAXTON, *Manager*

Vol. 126 JUNE 19, 1941 No. 25

THIS WEEK

• Waterworks preparedness is the theme of a special section in this issue, which includes some 20 pages of technical data of vital interest to every wide-awake waterworks engineer and official—ten articles containing suggestions for improving operating efficiency and the solution to many of today's perplexing problems. Some 750 companies and the products they supply for waterworks use are listed in a special section. A review of new equipment for waterworks service has been included as an additional feature.

• A first-hand report on British highways and rail transportation under war conditions by L. V. Murrow, highway director of the State of Washington, who is on leave for Army service, has just been made public by the Roads Committee of the U. S. Senate. An abstract of this report is given in this issue.

• New arc-welding methods and their application to steel frame construction are fast coming to the surface. Nearly all shop and field connections in the 2,600-ton steel frame of New York's Benjamin Franklin High School are arc-welded. Most interesting innovation is use of tee cord for the trusses, made by splitting deep beam sections along a joggled line to provide a lengthened stem of the tee at the panel points; virtually a gusset plate that is integral with the cord. The welding process is described by LaMotte Grover, structural welding engineer.

THINGS TO COME

• Continuing our series of articles on *Factories for Defense*—Wright Aeronautical's 50-acre airplane engine plant, the nation's largest one-story building, officially opened June 12, will be described in an early issue.

• Steel floor slab forms designed for an unsupported 10-ft. span, which lays without tools or ties, are being used on a 345-unit housing development at Hartford, Conn. These forms, which leave a continuous small burr, producing a plank effect on the exposed concrete of the room ceiling, will be described in the July 3 issue.

PAGE

The Week's Events 53

Reader Comment 59

Editorials 60

Novel Welded Details in New York School LA MOTTE GROVER .. 62

Handling a 20,000-Man Crew on a Camp Job 66

How a Cellular Concrete Bridge Acts Under Traffic F. W. PANHORST .. 69

Warsaw's Water Plant Destroyed 71

British Transport in War 72

More Durable Concrete with Treated Cement M. A. SWAYZE 74

Cantilever and Combined Footing Designs Compared H. S. WOODWARD .. 78

Cost of the St. Lawrence Project 79

Book Notes and Reviews 80

SPECIAL WATERWORKS SECTION

Preparedness Headquarters HARRY JORDAN 82

Industry Is Mobilized KARL M. MANN 82

War and Water Service NORMAN J. HOWARD 83

Trouble Shooters at Work J. S. LONGWELL 84

Sentinels of Service PAUL LIPPERT 87

Pooling Water Resources CHARLES H. CAPEN 89

Clean Mains and More Capacity CLINTON INGLEE 91

Main Sterilization H. N. ARMBRUST 93

Distribution System Diagnosis EDGAR K. WILSON 95

Water for Fire Fighters 97

From Field and Office 99

Unit Prices 102

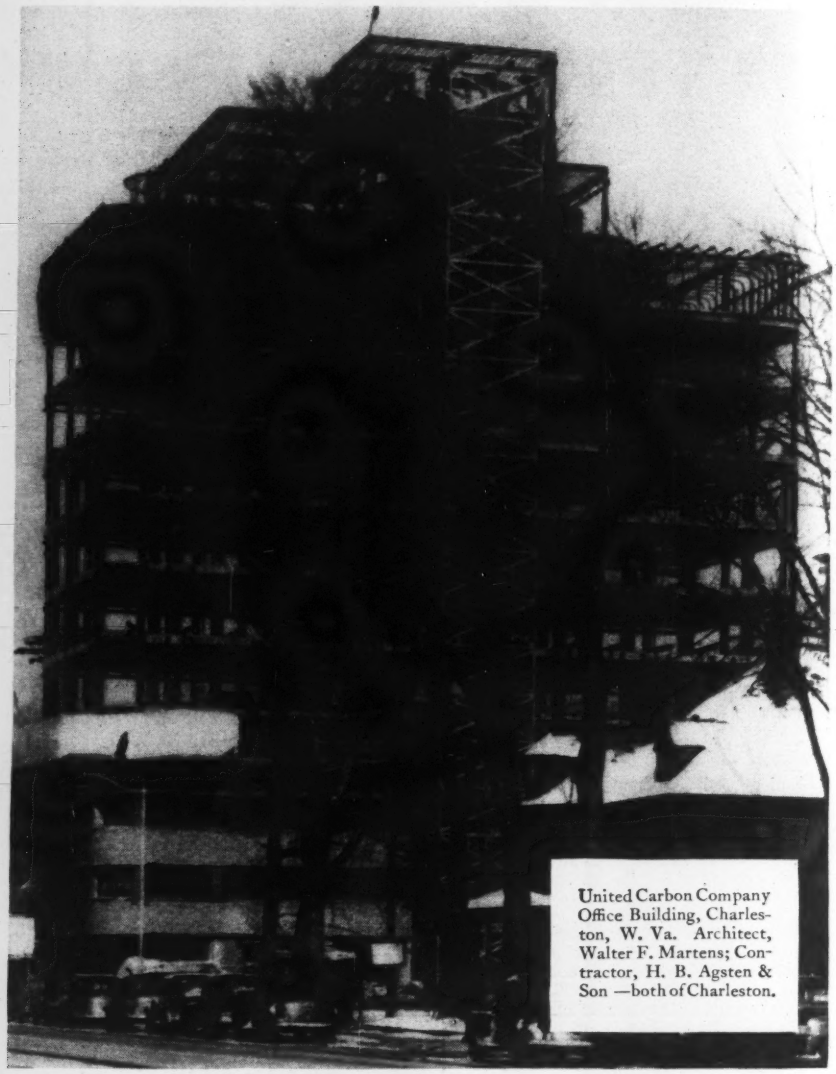
New Equipment in Review 106

Roster of Products 127

Construction Reports 165

Number of copies of this issue printed: 35,888

SAVED 2 SETS OF FORMS— 72 DAYS



United Carbon Company Office Building, Charleston, W. Va. Architect, Walter F. Martens; Contractor, H. B. Agsten & Son —both of Charleston.

How Atlas High-Early cement helped to reduce costs and speed construction of this 12-story building

HERE'S a story of large savings in money and concreting time on this new office building. In reporting these savings after a careful study of his records, contractor H. B. Agsten & Son stated that Atlas High-Early cement helped in these ways:

TIME SAVED: 6 to 7 days concreting time on each floor. Total saving, 72 to 84 days!

FORMS SAVED: 2 complete sets of forms because Atlas High-Early cement permitted earlier stripping and reuse of forms.

FUEL COSTS: Saved $24 per floor for coke used to heat concrete during curing, a total of $288 on fuel.

Whenever speed in construction is necessary or economical, it will pay you to consider Atlas High-Early cement. Send for a copy of the booklet "Case Histories of Days and Dollars." It shows how many contractors have produced serviceable concrete in much less than the usual time—how it has saved them time and money on all kinds of jobs! Universal Atlas Cement Co. (United States Steel Corp. Subsidiary), Dept. NR-6, Chrysler Bldg., N. Y. C.

OFFICES: *New York, Chicago, Phila., Boston, Albany, Pittsburgh, Cleveland, Minneapolis, Duluth, St. Louis, Kansas City, Des Moines, Birmingham, Waco.*

NR-H-35

ATLAS HIGH-EARLY CEMENT

A UNIVERSAL ATLAS PRODUCT

The Week In Engineering and Construction

ENGINEERING NEWS-RECORD • JUNE 19, 1941

TVA will get $40,000,000 to boost defense power output

Four new dams authorized and future plans anticipate construction of three more. By the end of 1942 TVA system will have a power capacity of 1,770,000 KW.

Four dams for power and storage to be built by TVA were authorized in a $40,000,000 appropriation bill passed by the House last Friday and expected to pass the Senate and be signed by the President during this week. Ultimately the new work will require $51,000,000. Two of the dams are on the Hiwassee River and two on its tributaries. The Hiwassee enters the Tennessee River above Chickamauga Dam near Chattanooga.

Installed power capacity will total 102,000 kw. at two of the four new dams and about 108,000 kw. in added units at existing plants, probably at Hiwassee and Wilson dams. This will bring the installed capacity of the TVA system to more than 1,770,000 kw. by the end of 1942, a total addition during the next eighteen months of 510,000 kw.

Further expansion planned

Meanwhile, it was revealed that the Office of Production Management is working on a much bigger program for further power development by the TVA. This would call for construction of three dams and additional generating units at existing dams at a total cost of about $118,000,000. The expanded program, which seems likely to go to Congress in a few weeks, is part of the effort to increase aluminum output to 1,600,000,000 lb. a year to carry the new bomber program.

This further program will include construction of Fontana Dam—originally intended to be built by the Aluminum Co. That plant would have an installed capacity of 150,000 kw., and together with 150,000 kw. of additional generators downstream, would cost some $54,000,000; it would take three years to build. Power could be obtained late in 1943 from two smaller dams contemplated. One, with 75,000-kw. capacity, would be on the South Fork of the Holston River near Bristol, Tenn. The other, 60,000 kw., would be on the Watauga River near Elizabethton, Tenn. Together, they would cost $44,000,000.

The new projects

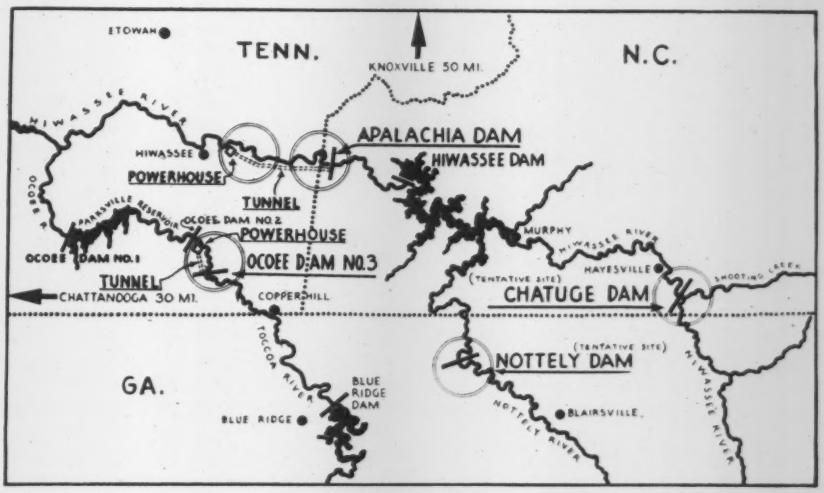
Principal structure of the new work will be Appalachia Dam on the Hiwassee River about twelve miles downstream from Hiwassee Dam. The design of the structure has not been definitely determined but it will be about 110 ft. high and may be either concrete or rock with an earth core. Below the dam a tunnel, lined diameter about 19½ ft., will carry the water 43,000 ft. to a power plant developing a total head of 385 ft. Installed power capacity will be 75,000 kw. with about 50,000 acre-ft. of storage provided above the dam. Total cost is estimated at $20,000,000.

The Nottely project on the Nottely River just south of the Georgia line will provide a storage reservoir of 200,000 acre-ft. above the Hiwassee Reservoir. The dam will probably be an earth fill, faced with rock, and about 150 ft. high. The project will cost $5,000,000.

The Chatuge Dam, also above Hiwassee Reservoir, will be of earth and rock fill construction, and about 150 ft. high. It will also store about 200,000 acre-ft. from a 190 sq. mi. drainage area. Estimated cost, without the future power plant, will be about $5,000,000.

On the Ocoee River, a few miles above the Ocoee Dam No. 2 (acquired from the Tennessee Electric Power Co.) Ocoee Dam No. 3 will be constructed. The structure is expected to be 100 ft. high with a concrete section 610 ft. long, including seven 32-ft. 6-in. tainter gates in a spillway section. A 13,000-ft. long, 12-ft. 6-in. diameter concrete lined tunnel will carry the water to a power house on the lake above Ocoee No. 2, developing a head of 300 ft. The project, including a 27,000 kw. generating unit will cost $6,600,000.

In addition to the new projects the added storage makes it desirable to add a unit (provided for in the original construction) at Hiwassee Dam, making the installed capacity about 115,000 kw. It is probable that two more units will be installed at Wilson Dam, bringing to six the number now being added to the original installation of eight. The added units are expected to cost $5,400,000. New substations and transmission lines will add $9,000,000.



New TVA dams to be built on Hiwassee River system

Senate passes $150,000,000 community facilities bill

The community facilities bill, providing $150,000,000 of public works to aid defense-expanded localities, passed the Senate last week substantially in the form in which it had already passed the House. One change eased the restrictions on communities eligible for help; the House version had said that federal public works should only be furnished in communities where they could not otherwise be provided, but the Senate added "or could not be provided without the imposition of an increased excessive tax burden or an unusual or excessive increase in the debt limit." It was also specified that private agencies, which may receive grants under the bill, must be of a non-profit nature. The bill is now in conference.

• • •

OPM gives approval to St. Lawrence project

Formal approval of the St. Lawrence power and navigation project (*ENR* May 22, p. 823 and June 12, p. 909) was given by the Office of Production Management on June 10. In a brief statement it said: "William S. Knudsen, director general, Office of Production Management, today announced that OPM has formally approved the St. Lawrence Waterway project as part of the all-out defense effort. The approval covered both waterway and electric power phases of the project."

Hearings on legislation to put the St. Lawrence agreement of March 19 into effect were begun June 16 by the Rivers and Harbors Committee of the House.

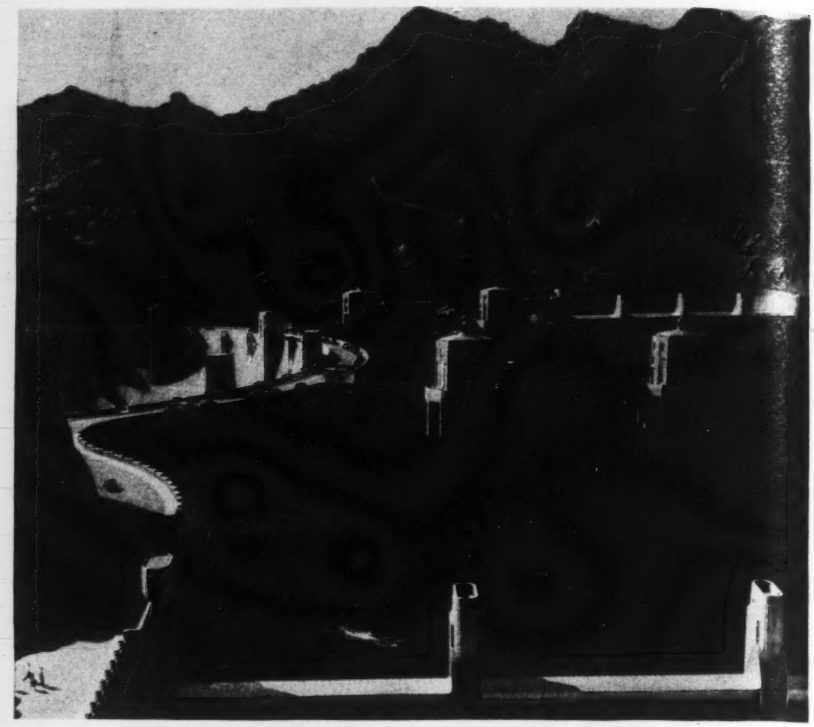
• • •

More generators asked for Columbia River projects

The engineering consulting board of the Bonneville Power Administration has reported to Administrator Paul J. Raver that preliminary studies of the Pacific Northwest power problem indicate a need for immediate installation of full complements of generators at both Bonneville and Grand Coulee dams on the Columbia River.

The board informed the Administrator that they were confident that all of the power capacities of the two dams—518,400 kw. at Bonneville, 194,000 kw. of which is installed, and 108,000 kw. which is now under installation; and 1,900 kw. at Grand Coulee dam, of which more than 300,000 kw. is now under installation—would be taken up by industries as quickly as it is developed.

Members of the consulting staff include: Charles E. Carey, chief consulting engineer and assistant chief of the division of market development and system planning for the Administration; Samuel B. Morris, dean of the school of engineering at Stanford University and water consultant for the national resources planning board; E. A. Loew, dean of the college of engineering of the University of Washington; Eugene C. Starr, professor of electrical engineering at Oregon State College; and Dr. Joseph S. Carroll, professor of electrical engineering at Stanford University and director of the Ryan High Voltage Laboratory. The board functions in an impartial advisory capacity to the Administrator and assists in programming the development of the power resources of the region. At present the board is reviewing the plans for expansion and development of the power grid system.



Lake Mead to spill at Boulder Dam this month

Late snows in the high mountains of the Colorado River watershed have raised the water of Lake Mead to a new high level at 28,000,000 acre-ft., and it is expected to spill at Boulder Dam for the first time this year. The spillway drum gates have been floated.

Lake Mead started the flood season with about three-fourths of its 32,359,274 acre-ft. of capacity occupied, which meant that the water level was 50 ft. below the maximum water level. When the snows began in April, releases were increased from about 12,000 sec.-ft. to 25,000 sec.-ft. On May 10 it was decided to increase the releases still more to an ultimate 35,000 sec.-ft. At present, June 3, the releases exceed 32,100 sec.-ft.

Weak points in the lower river channel have been revealed by the increased releases, despite the fact that they represent only about one-quarter of the peak flow which would have occurred had Boulder Dam not been in operation. Bank washing at Needles, Calif., has been the most serious trouble to develop, although some reports from Mexico indicated that newly reclaimed lands in the delta of the river were being threatened.

The maximum anticipated water level for the year is expected now to rise to six feet above the spillway crests; this means that about 24,000 sec.-ft. will be pouring through the spillways at the peak. The remainder of the 35,000 sec.-ft. release will be made up of releases through the outlets and the powerhouse penstocks.

Federal Power Commission approves Clam River Dam

The Federal Power Commission, acting upon a declaration of intention filed April 9 by the Clam River Dam Co. of Grantsburg, Wis., has entered a finding that the interests of interstate or foreign commerce will not be affected by construction of the proposed dam on the Clam River in Burnett County, Wis. This ruling of the power commission eliminates the necessity for a federal license for construction of the dam.

Plans for the project call for a dam 30 ft. high and approximately 970 ft. long, a concrete spillway and power house section 105 ft. long, and the remainder earth fill.

A.G.C. tackles contractor's problems and plans research for future work

Association launches construction research institute at White Sulphur Springs looking ahead to post-emergency period

Meeting in competition with the National Fertilizer Association at White Sulphur Springs, West Va., last week, the Associated General Contractors of America held their own on all fronts, gave the serious current problems of the contracting industry a thorough going-over, and looked beyond the present emergency by organizing a construction research institute for planning work to follow the defense building era. All those present realized the gravity of present issues, such as labor supply and labor relations, priorities, government contracting and construction procedure, including the trend toward perpetuating WPA under the guise of national defense, need for special contract provisions on private work under the unlimited national emergency, and the urgent need for a sound public relations program. These topics received full consideration at the meeting.

Planning ahead

Plans that may prove the most important ever made by the A.G.C. were laid in the organization of a construction research institute to plan for the markets of contractors, especially work to be done following the current building for defense. The plan was presented by A. P. Greensfelder, St. Louis, following an outline he gave at the annual convention in Houston last spring, entitled "Go Places or Go Broke." As finally adopted, the plan calls for voluntary contributions by contractors, based on the volume of work done the next three years, to an endowment fund. Only the income from the fund is to be used for operating the plan, except that up to $10,000 per year for the first three years may be taken from the capital fund for operating expenses. The institute will be formally established when $100,000 has been subscribed. Seven trustees are then to be appointed by the A.G.C. governing board. Present rules are very flexible, permitting the institute to receive funds from outside sources and to cooperate with other public, quasi-public and private agencies in planning construction activities.

In his opening remarks M. W. Watson, president of the A.G.C., declared the contractors have no apologies for the work they have done in national defense, pointing out that construction is about the only defense activity that is up to schedule. He pledged the association to full cooperation with the administration and military authorities in carrying out any assignment that may be handed to contractors. Following a plea by Horace Peters, representing the U. S. Treasury Department, for cooperation in purchasing defense bonds, a resolution was passed pledging such cooperation. Discussion followed as to possible means of calling attention of construction workers to the purchase of stamps and defense bonds, including setting up facilities for selling them at job pay windows.

Defense problems

The problems of contractors operating under the defense construction program and the unlimited national emergency were outlined by H. E. Foreman, managing director of the association. He stated in part: "This association, conceived as a result of a demonstrated need following the last war, has consistently striven to give its full cooperation to all those having in charge any part of this mammoth (defense) program. . . . From the very start the construction industry has achieved results that are a modern miracle." The fixed-fee type of contract, he pointed out, has been misunderstood by the public, and has been a headache to contractors in many instances, but he regarded it as probably the best contracting procedure to use in the rush of getting the defense program started. One point he mentioned, that of renting equipment to the government under this type of contract, later stirred up violent discussion because of the recapture clause in the rental provisions. Contractors are being stripped of their equipment by this clause, and are unable to obtain new equipment, practically putting some of them out of business. Always present was the fear that the government will utilize this recaptured equipment on future day-labor and WPA operations. The staff and officers were advised by the meeting to seek a change in the recapture clause to permit contractors to retain the equipment.

Apparently weary of the six-year fight against WPA, the association showed a tendency to change its tactics from fighting this agency on the front at Washington to battling back home the further inroads into contracting. It was realized by part of those present that an educational program and public relations activities at home would probably be more effective in ultimate liquidation of WPA. Others admitted the contractors must offer some alternative to WPA for taking care of the relief load. In some sections of the country the contractors are involved in contract-WPA programs, in which the contractors manage the projects, furnish supervision, equipment and skilled labor, but there was no undivided opinion expressed that this is the ultimate solution to the WPA problem.

Public relations

Many of the troubles and problems discussed on the floor showed the need for a sound public relations program on the part of the contractors. Such a program was outlined at the Houston meeting, but response to financial requirements has been disappointing. However, most encouraging is the work many of the chapters are doing in local public relations and publicity. It is hoped that as more of the chapters engage in this work, the need for nation-wide public relations, directed from the Washington office, will somehow be met. Meanwhile, the quest for funds for the national program will continue.

Discussions of labor matters indicated the construction industry has been little plagued by labor troubles so far in the defense program. Strikes and disputes have been rare in comparison with those in other industries. At present contractors find ample supply of labor available, except in a few isolated cases, but few cared to predict what the future may bring in this respect. The association will try to clear up a perplexing point, that of different agencies of the government citing different wage scales in the same communities.

The meeting was entirely a contractor affair and was not addressed by any outsider, except Mr. Peters of the Treasury Department. The fall meeting was scheduled for Detroit, and if the annual convention is held next spring it will probably be in Seattle, Wash.

• • •

Soundings for Mississippi River Bridge to be made

Bids have been received and contract will soon be awarded for taking soundings to determine the probable location of the proposed Mississippi River Bridge, at Memphis, Tenn. Two points have been selected, one in north Memphis, and the other, beside the present bridge.

Herman M. Stanley Co. of Dallas, Tex., is the low bidder for the proposed sounding work, according to announcement by the Memphis and Little Rock Bridge Commission.

Tentative plans for the new bridge project call for a structure to carry four or possibly six traffic lanes. Funds for the bridge are to be provided principally by federal aid out of the government allocation to the states of Arkansas and Tennessee, with Crittenden and Shelby Counties and the City of Memphis participating in the cost.

Texas flood takes out dam and inundates wide areas

The recent flood conditions in wide areas of Texas have resulted from rains which began early in May and continued almost without interruption through the first part of June. Rainfall records for the entire state indicate that the intensity of the recent rains were not unusual, but the heavy precipitation extended over such a long period that ground saturation was a major factor in producing the heavy runoff.

Another fact connected with the series of flood conditions was that the ordinarily dry areas of the extreme western part of the state, especially in the Panhandle and the South Plains, received more than one-half of their average annual rainfall during May and the first ten days of June.

The Trinity River at Dallas reached a height of approximately 43.4 ft. which was several feet above flood stage. The record stage of the river at Dallas was in 1908 when it reached a height of 52.6 ft. At that time there were no protecting levees for the business section, as shown functioning in the illustration (left). Unprotected sections of the city, including industrial districts, were flooded. Since the levees were constructed the highest stage, until the recent flood, was in 1935 at 42.1 ft. In 1938 the Trinity River reached a flood stage of 41.3 at Dallas.

At Greenville, in North Texas, the Sabine River overflowed and inundated thousands of acres of lowlands. It caused similar damage in the valley along its course below Greenville. The flood blocked traffic on highways and caused many people to leave their homes. At various points in north Texas the Brazos River rose to almost unprecedented levels, and at Graham it flooded the municipal water plant.

Comparatively small damage was done to highways and bridges, according to the Texas State Highway Commission. Many water storage dams, both public and private, in the flood areas came through the deluge without damage. The only notable exceptions were Lake Diller dam which formed a reservoir for the municipal supply of Albany, and a smaller private dam located near it. Lake Diller dam, which had a height of 32 ft. collapsed along its 1,300-ft. length and the water, increased by the breaking of the small private dam, swept down on the town of Albany, washing away thirty-five houses and damaging many others. Twelve persons lost their lives. This flood subsided quickly and the water was back within the bank of the creek in a few hours.

Originating in New Mexico and spreading eastward, the first heavy increase of rainfall was noted at Red Bluff dam near the Oklahoma border a few miles north of Pecos, Texas. The official record of the rate of flow into that reservoir on May 24 showed the water level reached a peak stage of 28.4 ft. This was slightly higher than the peak stage of 28 ft. reached in October, 1904.

Austin gets 8.6 in. of rain

On the night of June 6, Austin and adjacent area received 8.6 in. of rain within about nine hours. The stage of the Colorado River at Austin is controlled by the flood control dam in that city and Buchanan Dam, about 60 miles north, both on the Colorado River, and the Marshall Ford Dam which is nearly completed, 15 miles above the city.

The Red River, along the northern boundary of Texas, was in flood, and at a point immediately north of Ringgold that stream had the highest rise in fifty years. Its flow had been above normal for several weeks prior to reaching the peak stage of 27.6 ft. on June 7. Floods of 1891, 1908 and 1935 reached high stage at 27.2 ft. The flood stage on the river north of Denison reached a peak of 23 ft. which was 1 ft. below the record flood of 1908.

Restrictions likely on non-defense housing

Congress to be asked for half billion more for defense housing. Material shortages seen

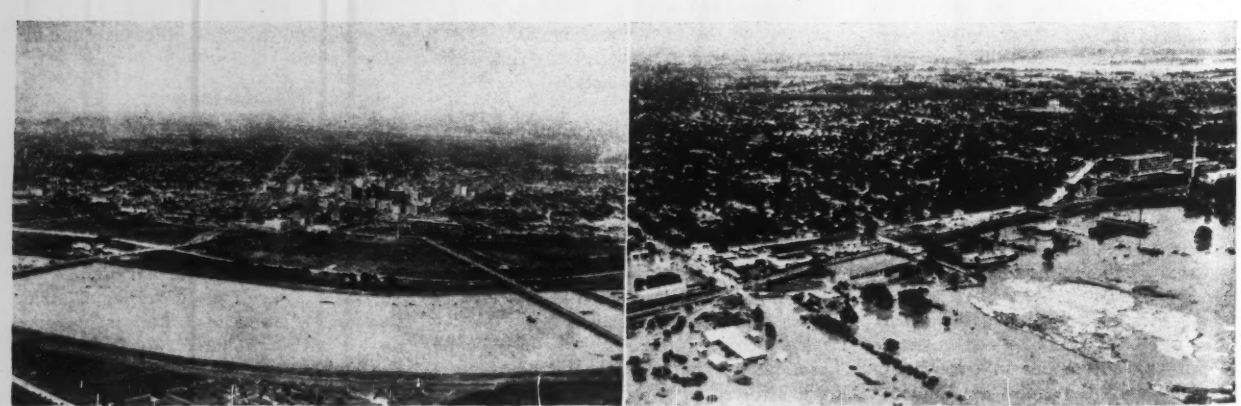
Possibility that residential construction outside defense areas might have to be forbidden was suggested last week by Housing Coordinator Palmer. Shortages of materials, he thinks, may make this necessary in order to insure housing for defense workers. During the coming fiscal year there will be a defense need for some 625,000 housing units. Palmer proposes to ask Congress for $500,000,000 with which to build 125,000 of these. This would leave 400,000 units to be built by private industry—probably making extensive use of the new no-down-payment FHA loans.

Control over other than defense housebuilding will probably be exercised, Palmer indicated, through the mortgage market by refusing credit facilities to houses outside defense areas and to expensive houses anywhere.

The same possibility of restriction on housebuilding has been raised by the Office of Price Administration and Civilian Supply. It is pointed out, for instance, that although some 34 billion board feet of lumber will be produced this year as compared with 29.5 billion in 1940, it may not be enough. The pending cantonment program will use about a billion and a half, expansion of industrial facilities will use a great deal, packaging and boxing needs are increasing rapidly, and defense housing will absorb most of that available for residences.

An absolute shortage of men in a construction trade showed up on the records of the U. S. Employment Service for the first time last month. The service, nationally, had more job openings for "steel framework connectors" than it could find men. This shortage is believed to be due to absorption of this trade into shipbuilding work, since there is a growing excess of construction workers in other trades.

New levee system protected the business section of Dallas (left) from the flood on the Trinity River. An unprotected industrial area (right) was flooded.



Drought continues throughout East setting record low-flow during May

Runoff shortages are persisting east of the Mississippi River and were intensified last month, with most severe conditions in the lower Ohio and Tennessee river basins

Shortages in stream flow which have persisted throughout much of the East since October 1940 have become more intense, and as a result substantial reduction of hydro-power generation has been necessary in regions where important defense industries are affected. Records collected at stream gaging stations of the Geological Survey indicate that the drought, although prevalent throughout the East, is most severe in the lower Ohio and Tennessee River Basins where stream flow during the month averaged only about 25 percent of normal and many streams receded to the lowest May discharge of record. The average deficiency in stream flow in the eastern United States was equivalent to about 1-in. depth of water, which in terms of power generation signifies a loss of about one billion kilowatt-hours of electrical energy or an amount equal to 40 percent of the hydroelectric power generation in this area during May of 1940. In order to meet this loss of available power in connection with the increased defense load, power sources have increased their steam generation, and where necessary old emergency standby equipment has been brought into use.

Although general rains throughout much of the East during the early part of June have afforded some temporary relief from the drought effects, they have hardly made an impression on the deficiencies in rainfall and runoff which have been accumulating throughout the winter and spring. Unless frequently augmented by substantial and timely rains further recessions in stream flow are to be expected throughout the summer and fall. The drought-making factors, namely deficient rainfall and high temperatures, were so severe throughout the East during the spring that in May the stream flow was in general the lowest May of record.

Situation by areas

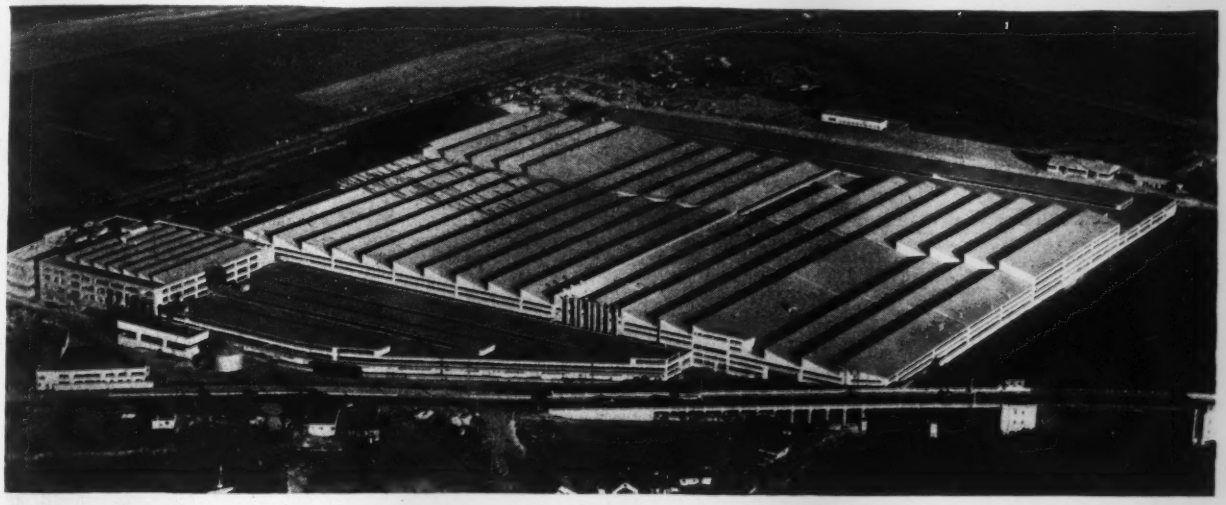
Stream-flow conditions in New England although greatly below normal are not yet critical, but the threat of an acute drought persists.

At the gaging station on the Piscataqua River at Dover-Foxcroft, Maine, a typical index station, the mean stream flow for May was 373 cfs. 29 percent of the normal of 1,280 cfs. The previous minimum of 442 cfs. was reached during May 1921.

In Massachusetts the yield of rivers as indicated by the discharge of Ware River was 68 percent of normal. Storage reservoirs in Vermont and Massachusetts filled little or none during May.

Areas most seriously affected by the current drought in New York lie along the southern boundary east of Binghamton, in the Catskill mountain region and in the south Adirondack region. Currently the stream flow in these areas is very materially below long-time averages as shown by the flow during the last week in May this year compared with long-time average.

Although there has been no serious shortage with respect to municipal and



Merit awards to workmen who built this plane factory

For distinguished service, some 2,156 construction workers and engineers whose combined effort was responsible for completion of the latest million-square-foot addition to the Boeing Aircraft Co. plant in Seattle, Wash., in 140 days have been cited by special merit awards by The Austin Co., engineers and builders of the project.

Total plant area at the Seattle site was less than 150,000 sq.ft. May 1940 when the first 660,000-sq.ft. addition was completed in 90 days last summer. (ENR Oct. 24, 1940 p. 566). Illustrated above is the present plant which today has more than 42 acres of floor space under one roof with a square foot area of 2,344,500.

In making the merit awards at an impressive ceremony on June 10, Richard Ellis, acting district manager of The Austin Co. organization in the Northwest, pointed to the record set in erection of this major defense project as evidence of the building industry's readiness to meet any tasks that may be placed before it in the defense emergency. Mr. Ellis emphasized the workmen's willingness to put up with all kinds of weather and with long hours, and paid tribute also to material suppliers, fabricators and the common carriers each of whom had a part in accomplishing this record construction achievement.

Almost coincident with this celebration marking completion of the Seattle plant, the Boeing company announced that it will immediately begin expansion of its new 384,000 sq.ft. factory at Wichita, Kansas, to more than four times its present size. The 1,320,600 sq. ft. addition will comprise two 300-ft. clear span production bays 1,00) ft. long and a 200 x 1,130 ft. warehouse area.

domestic supplies, considerable depletion of such supplies has occurred. Reservoirs in the Adirondack region are filled to 50 to 75 percent of their normal capacities. Reservoirs used for water supply in the Catskill mountain region were about 10 percent below normal at the end of the month as compared to 5 percent above normal at the beginning of the month. At the close of May, the flow of streams was generally being augmented by release of stored water from reservoirs. Without more than normal precipitation, industries depending to an important degree on the natural flow of streams and release of stored water will be seriously handicapped and conditions of domestic and municipal water supplies will become critical before the end of the summer season.

The Delaware River at Trenton also receded below the lowest May of record. Although drafts on storage for water supply have been the heaviest of record for the month, most of the important water supplies are reported ample and recent rains seem to have averted a potential drought. Increased industrial activity due largely to national defense work has, however, increased water consumption by about 10 percent over 1940 and water-supply conditions are being watched with interest. The flow of the Susquehanna River at Harrisburg, Pa., was about 35 percent of normal.

The May runoff of the Potomac River at Paw Paw, W. Va., but generally typical of Maryland conditions, was 30 percent of the May normal and was the lowest May for a period of 12 years of record. Precipitation and stream flow in Virginia approached the lowest May of record.

Deficient precipitation and excess temperatures were prevalent in North Carolina throughout May. The French Broad River at Asheville, N. C., averaged 972 cfs. during May compared to a normal of 2,040 cfs. for a 44-year period and a previous minimum for the month of 1,120 cfs. in 1898.

Rainfall for the month of May at Atlanta, Ga., was only 13 percent of normal. The flow of the Chattahoochee River at West Point, Ga., averaged 1,954 cfs. or only 41 percent of normal. It was the lowest May flow for a period of record going back to 1897. The previous minimum of 2,150 cfs. second-feet occurred during May 1914.

The flow of streams continued to decline in Ohio, and at some places approached the minimum May of record. The flow of the Scioto River at Higby, Ohio, was only 26 percent of normal and the accumulated runoff since October 1, 1940, has been only 36 percent of average. Stream flow in the industrial northeastern and southwestern parts of the state appears to have suffered the greatest deficiency.

The mean flow of the White River at Noblesville, Ind., was 92 cfs., 13 percent of normal. The previous minimum May during a 24-year record was 176 cfs.

Percentages of normal stream flow during May. Worse conditions are in dotted areas and underlined figures indicate record low deficiencies.

Precipitation in Tennessee during May has been about 20 percent of normal. The flow of the Tennessee River at Knoxville was 4,845 cfs. during May compared with a 41-year normal of 12,300 cfs. and a previous May minimum of 6,672 cfs. reached during 1940. The accumulated runoff in the 8-month period since October 1, was 6.63 inches, compared with a normal of 15.02 inches, or a deficiency of 8.39 inches. According to the Weather Bureau, since October 1 there has been an accumulated deficiency of rainfall at Knoxville of 13.54 inches.

A recent report indicates that intermittent rains in the Tennessee Valley during the past week have decreased the drawn-down rate in the reservoirs of the TVA system. However, rains have been insufficient to meet the current need for power with necessity for some drawing from the reservoirs contining.

The situation is expected to call for conservation of electricity through the entire summer, as TVA is supplying 150,000 kw. of firm power to the Aluminum Co.'s Maryville, Tenn., plant, in addition to the 30,000 kw. of firm power under contract. Power rationing is not believed an immediate prospect.

• • •

Pennsylvania Turnpike extension bill signed

A bill providing for the extension of the Pennsylvania Turnpike from Irwin, Pa., its western terminus, to the Ohio state line, has been passed by the Pennsylvania legislature and signed by Governor Arthur H. James.

Defense-highway bill approved by the Senate

Amount limited to $250,000,000 and federal share raised to three-fourths of the road cost

The Hayden-Cartwright defense-road bill this week passed the Senate with only two major changes from the form in which it was introduced (*ENR* June 12, 1941, p. 107). As predicted, the administration bill authorizing expenditure of only $125,000,000 for defense roads was thrown out by the committee, and the broad measure authorizing federal funds for access roads, improvement of the strategic network, flight strips, parking areas, advance planning of road projects, and payment for road damage done in maneuvers was reported out. The committee did however place a limit of $250,000,000 on the amounts which may be appropriated.

As introduced, the bill had set no limit on the permissible appropriation. In setting the quarter-billion limit, the committee expressed the belief that more than this would be needed but that this amount would cover the immediate requirements.

Federal share in the cost of improvements to the strategic network was increased by the Senate to three-fourths. As introduced, the cost would have been split equally between state and federal governments, but the committee increased this to a 2-1 ratio. The final 3-1 arrangement was adopted on the Senate floor. The bill still provides for allocation among the states of whatever money is appropriated for the strategic network in accordance with the usual federal-aid formula.

Access roads are to be paid for by the federal government. The section of the bill relating to these roads has been amplified to cover "access roads to military and naval reservations, to defense industry sites, and to sources of raw materials when such roads are certified to the Federal Works Administrator as important to national defense."

The present bill, which is still to be acted upon by the House, provides no money. Its passage would make possible the inclusion, in the next supplemental defense appropriation, of any amount up to $250,000,000.

• • •

New road work in Alabama to cost $4,877,000

Contracts for new road and grade crossing projects costing an estimated $4,877,000, will be let by the Alabama State Highway Department by Oct. 1, according to announcement by Highway Director Chris J. Sherlock.

This new work, $4,300,000 for roads and $177,000 for railroad crossings, does not include the nearly $1,188,000 in contracts already let.

Skinker made St. Louis water commissioner

Director of Public Utilities Max H. Doyne, of St. Louis, Mo., has just announced the appointment of Thomas J. Skinker as water commissioner of that city. Mr. Skinker takes over the former duties of John B. Dean, who had held the post since 1935. Mr. Dean has returned to his old position as division engineer in the supply and purifying section of the water section.

Max H. Doyne a consulting engineer, a civil engineering graduate of Cooper Union Institute who previously headed up the firm of C. E. Smith & Co. was recently appointed to his present position by Mayor Becker.

Mr. Doyne received his appointment following the resignation of Edward E. Wall. Mr. Wall had been employed by the St. Louis water department for 53 years, and had served as director of public utilities since 1925. A civil engineering graduate from Missouri State University, he had served as assistant engineer for the St. Louis water department, assistant water commissioner, and water commissioner, before being appointed to the post of director of public utilities.

• • •

New Boulder Dam power contract signed

Taxpayers and water users in the thirteen cities of the Metropolitan Water District of Southern California will be benefited by an annual saving of $832,000 during the next ten years, and an eventual total saving of $40,000,000, under the terms of a new Boulder Dam power contract which has been signed by Secretary of the Interior Harold L. Ickes.

Approval of the contract on behalf of the Metropolitan Water District has been voted by the district's board of directors. Acting on the motion of Director Victor H. Rossetti, the board approved a resolution highly commending General Manager and Chief Engineer F. E. Weymouth; James H. Howard, general counsel; and J. M. Gaylord, chief electrical engineer, for their public services in leading the long fight to secure a modification of the old power contract.

Under the terms of the new agreement the rate for firm energy at Boulder Dam is fixed at 1.163 mills per kilowatt hour, as compared to a rate of 1.63 mills per kilowatt hour under the original contract. The thirteen Metropolitan Water District cities which will share in the saving effected by the new Boulder Dam power contract are Los Angeles, Anaheim, Beverly Hills, Burbank, Compton, Fullerton, Glendale, Long Beach, Pasadena, San Marino, Santa Ana, Santa Monica and Torrance.

JOBS OF THE WEEK

SHELL LOADING PLANT, Minden, La.

Silas Mason Co., Inc., New York, N. Y., has been awarded contract by the War Department, Washington, D. C., for constructing shell loading plant on 10,000 acres between Doyline and Minden. Estimated total cost $30,000,000.

SUPPLY DEPOT and WAREHOUSE, Memphis, Tenn.

Mark K. Wilson Co., Chattanooga, Tenn., has been awarded contract for constructing quartermaster depot and warehouse by War Department, Washington, D. C. Estimated cost $8,000,000 on cost plus fixed-fee-basis.

SANTE FE DAM, Los Angeles, Calif.

Morrison Knudsen Co., Ford J. Twaits, J. F. Shea and Winston Brothers Co., Los Angeles, Calif., were lowest bidder for Sante Fe Dam, to be constructed below mouth of San Gabriel Canyon. The U. S. Engineers, Los Angeles, took bids June 12 and the low bid was $8,837,199.

AIRPLANE PROPELLER PLANT, Toledo, O.

Austin Company, Cleveland, O., will construct airplane propeller plant, on Terminal Railroad at cost to exceed $8,000,000. American Propeller Corp. c/o Aviation Mfg. Corp., New York, is owner. The Defense Plant Corp. will finance.

TNT MANUFACTURING PLANT, Chattanooga, Tenn.

Stone & Webster Corp., Boston, Mass., has been awarded contract for the construction of plant for the manufacture of TNT by War Department, Washington, D. C. Estimated cost $39,000,000.

AIR CORP TECHNICAL SCHOOL, Wichita Falls, Tex.

U. S. Engineer, Wichita Falls, awarded contract for the construction of air corps technical school to Robert E. McKee Construction Co., El Paso, $4,886,889.

HOUSING PROJECT, Detroit, Mich.

Cauldwell Wingate Co., New York, N. Y., has been awarded contract for constructing S. James Herman Gardens, Housing Project at $8,212,000. Detroit Housing Authority, Detroit, awarded contract. G. D. Mason Associates, Detroit, are architects.

EMBANKMENT and SPILLWAY, Piedmont, Mo.

Mittry Brothers Construction Co., Los Angeles, Calif., will construct embankment and spillway for Clearwater Dam, on Black River. U. S. Engineers, Little Rock, Ark., awarded contract at $2,790,081.

DEFENSE HOUSING PROJECT, Middletown, Pa.

M. Shapiro & Son, Inc., New York, N. Y., will construct one hundred fifty defense housing units on tract east of Middletown, for civilian workers at Middletown Army Air Depot, by Middletown Housing Authority. Est. $1,447,000. USHA.

AMMONIA PLANT, Henderson, Ky.

Semet Solvay Engineering Corp., New York, N. Y., has been awarded contract for gas plant at ammonia plant here, by Atmospheric Nitrogen Corp., New York. Other construction will be done by separate contracts. War Department will finance, and Atmospheric Nitrogen Corp. will operate plant. Total estimated cost $15,484,195.

TELEPHONE BUILDING, Providence, R. I.

E. Turgeon, Providence, R. I., awarded contract 8 story, 104x109x166 ft. telephone buildings for New England Telephone & Telegraph Co., Boston, Mass. Estimated cost $1,000,000. Hollis French, Boston, Mass., is engineer. Howe & Prout, Providence, R. I., are architects.

PACKERS CAB PLANT, Mankato, Minn.

Austin Company, Cleveland, O., will construct 1 story, manufacturing plant on Chestnut St., for Continental Can Co., Inc., New York. Estimated cost $1,000,000.

NOTE—Additional bidding and contract news on over 800 projects large and small appear in the Construction News section beginning on page 165.

OBITUARY

GRIER RALSTON SMILEY, 61, chief engineer of the Louisville & Nashville Railroad and nationally known authority on railroad construction matters, died June 11 at Miami Beach, Fla. Joining the L. & N. 28 years ago as a resident engineer, Mr. Smiley became chief engineer in charge of construction in 1920, was promoted to assistant chief engineer in 1931, and two years later was elevated to the position of chief engineer. He was a graduate of Washington and Lee University.

RAYMOND SCHRAEDEL, architect and construction adviser to the United States Housing Authority, died June 11, at Yonkers, N. Y. Mr. Schraedel was a graduate of Washington University, St. Louis, and served with the 314th Engineers in the World War.

WALTER R. BENNY, divisional engineer of the Canadian Pacific Railway, at Schreiber, Ont., was drowned when inspecting a flood-weakened culvert at Noslo, June 8.

ING. ANTONIO SUAREZ ARANZOLO, 40, prominent Mexican civil engineer, and brother of Lic. Eduardo Suarez Aranzolo, the Minister of Finance, died at his home in Mexico City recently.

W. K. MARTIN, 49, president of the W. K. Martin Construction Co., of Kansas City, Mo., died May 26.

ELMER E. LEE, 78, retired civil engineer, died recently at Rochester, N. Y.

LELAND RAY WATTIS, 62, prominent railroad constructor, died recently in Cottonwood, Utah.

FREDERICK LYON FELLOWS, 80, former chief engineer, for Vancouver, died June 9 at Vancouver, Canada.

MICHAEL J. BURKE, 70, died June 10 at Cleveland, Ohio. Mr. Burke was formerly president of the Gallagher-Burke Construction Co.

HENRY S. MARTENIS, 80, died June 8 at South Orange, N. J. Mr. Martenis was formerly superintendent of construction for the Delaware and Lackawanna Railroad, which he served for 47 years.

ANGELO OMEDEO, hydraulic engineer, died recently near Milan, Italy. Mr. Omedeo built the Turso dam in Sardina, the largest in Europe.

WILLIAM ALEXANDER WILSON, 82, consulting engineer, died June 7 at Salt Lake City, Utah.

ARTHUR CURTISS JAMES, railroad builder, died recently at Montreal, Canada.

HAROLD J. ST. CLAIR, 56, engineer, died June 4 at Leonica, N. J. Mr. St. Clair was employed by the Fuller Construction Co.

JOSEPH E. PENNOCK, 87, construction engineer, died June 6 at Philadelphia, Pa. Mr. Pennock's company built the Knickerbocker Hotel in New York and other large building structures throughout the East.

EDMUND J. KNECHTGES, mining engineer for the Inland Steel Co. at Iron River, Mich., was killed recently in an automobile accident.

ROY C. CAUL, civil engineer, died June 11 at Chicago. Mr. Caul was employed in the Track Department of the Chicago Surface Lines. He was a graduate of the University of Illinois.

CHARLES C. MACLEOD, civil engineer, died June 12 at Evanston, Ill.

MATTEO MARTINO, 81, former construction engineer, died June 10 at Watkins Glen, N. Y.

HARRY G. HAYS, 59, construction engineer, died recently at Miami Beach, Fla.

CONTRACTS AND CAPITAL

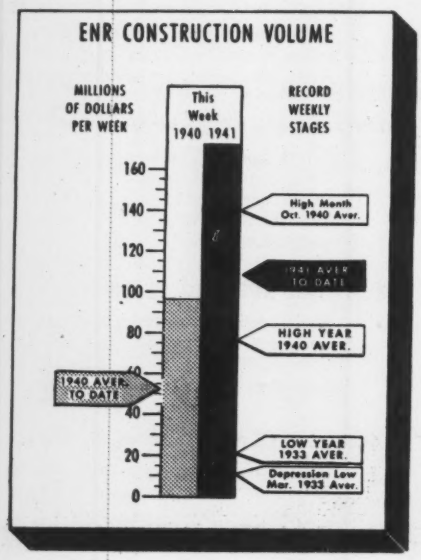
WITH THE SECOND phase of the Defense Program rapidly entering the contract stage, construction awards for the week, $173,306,000, reached the highest peak of the year, and the third highest total ever reported. The week's volume is 24 percent higher than last week, and 80 percent above the corresponding week last year.

Public construction is the highest since the record week of October 17, 1940, due to the all-time high public building volume. It is 40 percent above a week ago, and 163 percent over a year ago. Federal awards, the second highest on record, are responsible for the public gain. Private awards are 37 percent lower than last week, and 50 percent under a year ago.

The current week's total brings 1941 construction to $2,697,883,000, a 99 percent increase over the 25-week period last year. Private awards, $718,346,000, are up 52 percent compared with the 1940 period; and public construction is 124 percent higher as a result of the 532 percent increase in federal construction awards.

Four large defense projects—a $39,000,000 TNT plant in Chattanooga, a $30,000,000 shell loading plant in Minden, La., an $8,000,000 propeller plant in Toledo, Ohio, and an $8,000,000 supply depot and warehouse in Memphis, Tenn.—account for $85,000,000 of the record public building volume of $126,307,000. In addition to public buildings, sewerage, bridges, and highways report gains over last week; and sewerage, commercial buildings, and earthwork and drainage increase over the 1940 week.

New construction financing for the 25 weeks of 1941, $3,328,718,000, is up 440 percent over the total for the same period in 1940.



CONTRACTS

(Thousands of dollars)

	Week Ending June 20 1940	June 12 1941	June 19 1941
Federal	$35,930	$88,407	$128,310
State & Municipal	22,897	22,024	26,375
Total public	$58,827	$110,431	$154,685
Total private	37,459	29,394	18,621
TOTALS	$96,286	$139,825	$173,306
Cumulative 1941	(25 weeks)		$2,697,883
1940	(25 weeks)		$1,354,747

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1940 25 weeks	1941 25 weeks
NON-FEDERAL	$617,744	$437,381
Corp. Securities	88,718	133,625
State & Mun.	434,998	241,904
U.S.H.A. loans	87,204	30,399
R.F.C. loans	6,824	31,453
FEDERAL		$2,891,337
TOTAL CAPITAL	$617,744	$3,328,718

FHA MORTGAGES

	Week Ending June 15 1940	June 7 1941	June 14 1941
Selected for appraisal	$27,783	$31,459	$32,300*
Cumulative 1941	(24 weeks)		$684,982*
1940	(24 weeks)		$582,819*

* Subject to revision.

ENR INDEX NUMBERS

Index Base=100		1913	1926
Construction Cost	June '41	256.79	123.44
Building Cost	June '41	209.41	113.20
Volume	May '41	275	121

Comment and Discussion

Readers' opinions on matters that concern engineers and contractors

High-Yield Reinforcing

Sir: In reviewing the provisions of the then proposed building code for the City of New York in *ENR*, Aug. 19, 1937, the writer directed attention to the impropriety of the treatment and exclusive advantages therein granted to the use of patented cold-worked, twin-twisted high-yield strength steel. In spite of registered protests, these provisions were adopted and have been in effect since Jan. 1, 1938. At the present time there is pending before the Council of the City of New York a proposed bill to eliminate these exclusive advantages and to substitute a more conservative treatment applicable to all high-yield strength steels, with yield points in excess of 50,000 lb. per sq. in.

Subsequent to the promulgation of the original Columbia University test data of 1935 (followed later by tests at Lehigh and Princeton Universities) a second investigation was instituted in the testing laboratories of Columbia University in 1940 under the auspices of the Concrete Reinforcing Steel Institute and under the supervision and control of a special reinforced concrete committee of the New York Society of Structural Engineers for the purpose of determining the relative behavior of cold-worked twin-twisted and hot-rolled steel bars. These tests are now completed and will soon be published for the information of the profession at large. The committee of the Structural Engineers' Society has been studying the information for some weeks and will also issue an analysis of the results as a supplement to the factual test report of Columbia University.

Notwithstanding the hesitancy of the joint committee and also of the American Concrete Institute to recommend working stresses in excess of 20,000 lb. per sq. in. for reinforcement because of fear of excessive deflection and tension cracking of the concrete, observers of these and similar flexure tests of reinforced concrete beams designed by the common theory of flexure feel that some stress increase is justified. And New York is prepared to show the way.

In general, the ultimate beam loads in the Columbia tests (as in many other tests) are higher than predicted by the concrete cylinder strength. Notwithstanding this, however, the specifications of the present New York City Code, as they relate to the use of patented twin-twisted steel of low percentage of reinforcement, lead to a double error, in permitting an arbitrary increase in concrete stress plus an indirect increase resulting from failure to specify the correct value of the modulus of elasticity of such steel. A more liberal treatment of structural members reinforced with high-yield steels as now proposed by the New York authorities is undoubtedly indicated. The writer believes that the profession in general should take cognizance of and lend support to the adoption of the pending legislation by the Council of the City of New York under Introductory Bills No. 517, 518 and 519.

One of the important activities of the Structural Engineers' Society of New York is its cooperation with the building authorities in the interpretation and amendment of the building laws, to secure coordination between the practicing engineer and the supervising authority, and to maintain building regulations in step with engineering advance. The exercise of this function is of mutual advantage to all interests of the building profession, and the members of this group, being actively engaged as consultants in structural design, are especially qualified to perform this service. Code and legislative committees are maintained for this purpose and now have several proposed code revisions under advisement.

GEORGE E. STREHAN
Consulting Engineer
President, Structural Engineers Society of New York

A Training Short-Cut

Sir: Recently in your "Comment and Discussion" column there was a statement concerning an engineer getting his training from mail order houses.

For his enlightenment, out in Kansas the accepted short-cut to an engineering education and career is to get smitten across the rump with a level rod a few times, and to purchase a pair of boots.

J. J. WARDRIP
County Engineer
Elk County, Kan.

Two-Course Paving Slabs

Sir: Several years ago, the Public Roads Administration conducted a series of tests on a group of cylinders or cores cut from highway slabs involved in a test on New York state highways for resistance to freezing and thawing and ice removal chemicals. As the test proceeded, they found they had no trouble with the lower 6½ in. of a 9-in.-deep core regardless of the cement used. Why?

In the laying of a 9-in. slab, the concrete is dumped into the pit, leveled off with a hand screed to a depth of 6½ in. This concrete is in direct contact with the sub-base. On this is laid a steel wire mesh and the balance of the concrete placed, roughly spread, and worked with the first and second mechanical vibrating screeds. After this the hand finishers complete the work.

The conception of the modern vibrating screed is that the motion, elliptical in its procession, travels over the concrete in a series of parallel force waves to the bottom of the slab. This is not the case as the bottom of the force wave tapers to a point at the contact with the soil. The PRA tests showed the maximum loss at the surface, tapering off to the steel mesh line at 2½ in. Therefore the apex of the elliptical advancing force wave would seem to be 2½ in. from the surface, and the top 2½ in. of the slab is definitely over worked.

Is a slab made in this manner monolithic? Do we have a construction joint horizontally in the slab? Is the steel essential to good slab construction? Does it add to or detract from the durable quality of a slab?

Why not try some slabs without steel—9 in. thick for full width, placed full 9 in. leveled off with rough screed, permitted to cure for a reasonable length of time and the surface ground to a riding finish.

The results of the tests referred to above were published by the Public Roads Administration and also in the *Proceedings* of A.S.T.M.

CHAS. L. KIRK
Vice-President
Eddystone Portland Puzzolan Cement Co.
Pittsburgh, Pa.

EDITORIALS

VOLUME 126 NUMBER 25

June 19, 1941

Waterworks Preparedness

WATERWORKS MEN have a lot to think about—and do—these days. Sources of supply and plant facilities are being called upon to measure up to unprecedented demands created by industrial and community expansion. Responsibilities are broadened by the necessity of safeguarding systems from sabotage and providing for other emergency conditions. Defense production is restricting the availability of waterworks equipment and supplies. And to top off the difficulties, Nature capriciously has ordained a drought in vital areas. This, in brief, is the situation in which waterworks men find themselves in the year 1941 A.D. Extraordinary problems are presented, and this issue presents in two special sections data helpful to their solution. In the first, on "Waterworks Preparedness," practical articles contain suggestions for improving operating efficiency, and in the second, "Roster of Waterworks Products and Services," is given for the first time a listing of some 750 companies and the products that they supply for waterworks use. In this period of emergency when time is of the essence, when new operating problems arise and when one or another normal source of equipment or material supply is blocked, this issue should have special value.

No Letup

JUST A YEAR AGO the construction industry entered upon the task of creating facilities with which we could transform our peaceful nation into an armed camp and an arsenal. Now completed, with commendable speed and thoroughness, this task, multiplied in several of its important phases, must be met again. And perhaps again and again, for the objective tends to recede even as we seem to attain it. This month the new contracts began to appear. Training camp facilities are to be doubled. Aluminum production plants must be trebled. Required capacity for making powder, shells, tanks, bombers and guns has no upper limit that anyone dares to fix. Electric generating plants must be able to produce 10 million more kilowatts. Merchant shipbuilding must expand four or five times. There is not enough steel, magnesium, railroad car or rubber manufacturing capacity. In brief there is to be no letup in construction for at least another year. And this next job must be more efficient than the last. It must be speedier. It must be freer of causes for political investigation. It must be the best job in every respect that the construction industry has ever turned out. Nothing short of that goal is a worthy objective.

Looking Ahead

BUSY AS THEY ARE with building for the nation's defense, the Associated General Contractors are looking ahead to what comes after. Convinced that a terrific let-down in their business faces them eventually unless sound planning is started now, the contractors, assembled at White Sulphur Springs last week, launched a construction research institute that may prove their salvation. Successful inauguration of the venture depends upon response to a call for contributions to the endowment fund. Several governmental agencies are already planning for the period following the emergency, and construction figures prominently in all such plans. Whatever may come in construction, there is a place for contractors if they help plan it that way. The proposed construction research institute offers an opportunity for contractors to cooperate in future planning and, as its originator, A. P. Greensfelder, points out, it offers a choice: to "go places or go broke."

Start Defense Roads Now

ROAD PLANS are moving ahead rapidly in Congress. Senator Hayden and Representative Cartwright, leaders of the road authorities in Congress, are ignoring the President's message of June 2 with its very limited recommendations, believing that legislation written at this time should be so broad as to cover any needs that may develop as our defense program expands. And to reinforce the belief that the road program recommended by the President is inadequate comes the report of Lt. Col. L. V. Murrow on British experience with defense roads, abstracted in this issue. The British have learned, when it is too late to do much about it, that adequate highways are a major factor in defense, that they are much less vulnerable than railways to air attack, and much more quickly repaired. Before the war the British confined their road work to improving their existing system;

they know now that they should have built a new system designed for motor-vehicle use, not for horse drawn vehicles. Our present system is much more modern than theirs, but our motor-vehicle use is much more intensive. We should not wait until we lack both men and equipment to build a defense road system adequate to our needs. The time to start is now.

St. Lawrence for Defense

THAT THE ST. LAWRENCE SEAWAY and navigation project will be undertaken as a defense measure now appears highly probable. Approval by the OPM added to the President's strong indorsement doubtless will produce the majority vote that is needed in Congress.

In emergencies such as the present one it is necessary for all of us, when we find ourselves in disagreement with the President and the OPM on matters affecting our defense effort, to assume that their knowledge of the nation's needs is more profound than our own. When they say that the St. Lawrence power and navigation facilities are essential to our defense efforts they say indirectly that they anticipate that the peak of our defense effort will not be attained until some four or more years from now. Such being the case, our whole thinking with respect to defense requirements must be altered. So far as this journal is concerned, it will accept the OPM statement that "both the waterway and electric power phases of the project are necessary as part of the all-out defense effort."

Acceptance of the OPM's finding, however, does not remove our objection to the inequitable and indefinite agreement of March 19 under which the President proposes to undertake the project. That agreement does not fully protect this country's water and power rights nor does it assure that the Canadian sections of the seaway will be completed in less than seven years. (See *ENR*, May 22, p. 830).

Assuming that the St. Lawrence power is needed for defense, then the agreement of March 19 has still another shortcoming; it does not call for the speedy development of the Niagara-St. Lawrence power resources that is essential in the present emergency. Viewing the project as part of an "all-out defense effort," in which the two nations are willing to pool their assets regardless of where they happen to be, the agreement should call for progressive development of *all* of the river's resources in the order in which they can most readily be made available. The most readily available power resources are those at Beauharnois in Quebec, about 50 miles downstream from the projected international plant at Barnhart Island. The first step in a development program, therefore, should be expansion of the Beauharnois plant to its full capacity of 2,000,000 hp. This will provide about 1,400,000 hp. in much less time than it will take to build the Barnhart Island plant.

A second step would be inauguration of over-all development of the Niagara power resources on the New York side and expansion of the existing over-all development on the Canadian side. None of the plants on this side at Niagara uses the full head that is available, and some of the old plants on both sides, which have been put back into service in the present emergency, make very inefficient use of the water. About 1,000,000 hp. could be added by more efficient use of Niagara water, and probably more quickly than at Barnhart Island. Meanwhile, work on the Barnhart Island plant would be put underway along with work on the seaway.

Turning to the seaway aspect of the project, it is only common sense to insist that work on the entire seaway from Lake Ontario to Montreal be undertaken for simultaneous completion of both the international and Canadian sections. The agreement of March 19 gives Canada to Dec. 31, 1948, to complete its section should the pressure of war work make that necessary. That provision should be eliminated. It is folly to procrastinate if the seaway is to be a part of the current war effort.

Such a program of development holds no insurmountable obstacles. A new agreement should not require more than a few weeks to negotiate. It would protect our rights. It would give Canada the financial help that she needs. It would provide power for both countries in the minimum possible time. And it would assure a seaway that would join the Great Lakes with the sea instead of just with the Canadian border. If the President and the OPM want the nation to take this project on their word of its necessity, the least they can do is to plan and program it with a realism that engenders confidence in its usefulness for this war and not for some indefinite time in the future.

ENGINEERING NEWS-RECORD
Copyright 1941, by McGraw-Hill Publishing Company, Inc.
WALDO G. BOWMAN, *Editor*. J. I. BALLARD, *Managing Editor*. *New York:* V. T. BOUGHTON, E. J. CLEARY, A. N. CARTER, H. W. HUNT, E. R. DENMARK. *Chicago:* H. W. RICHARDSON. *Washington:* PAUL WOOTON, R. B. COLBORN. *San Francisco:* N. A. BOWERS. *Consulting Editors*, F. E. SCHMITT, W. W. DeBERARD
EDITORIAL OFFICES: 330 WEST FORTY-SECOND STREET, NEW YORK, N. Y.

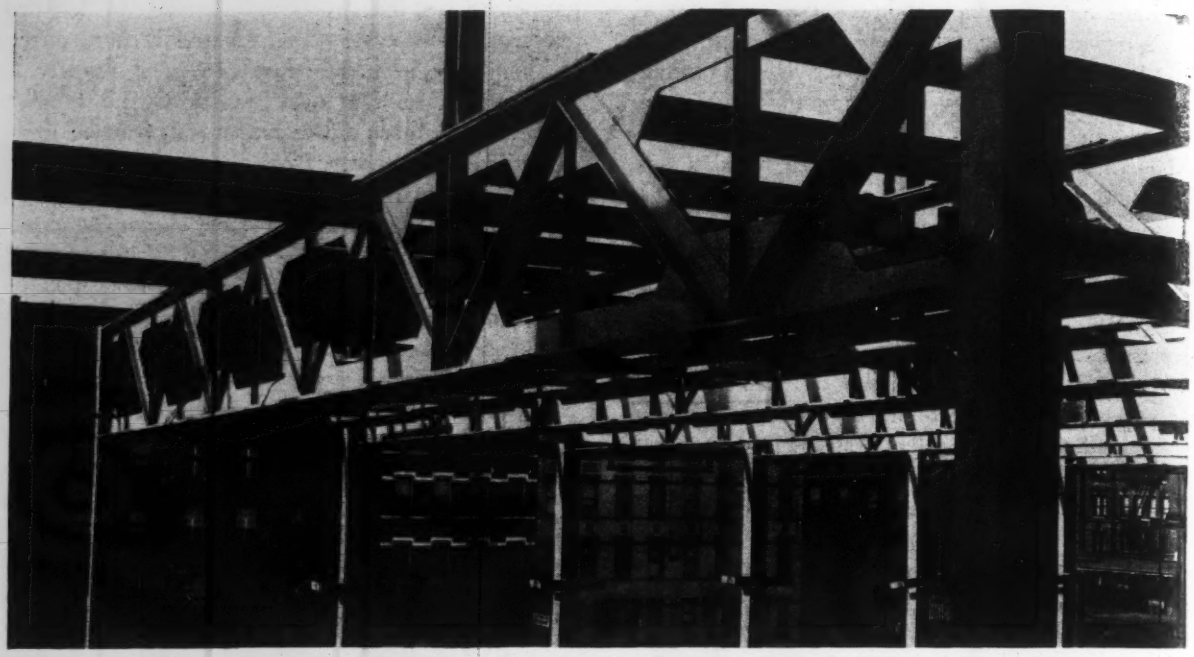


Fig. 1. One-piece tee chord and "gusset plate", made by splitting a beam section, distinguishes this welded truss.

Novel Welded Details in New York School

La Motte Grover

Structural Welding Engineer, Air Reduction Sales Co.
New York, N. Y.

***Contents in Brief**—All shop and main field connections in the 2,600-ton frame of the Benjamin Franklin High School are arc-welded. Twin cantilever girders carry the auditorium balcony. Trusses weigh up to 19 tons and have spans up to 79 ft. Some connections carry 515-kip reactions. Most important innovation is use of tee chords for the trusses, made by splitting deep beam sections along a joggled line to provide a deeper stem of the tee at the panel points, virtually a gusset plate that is integral with the chord.*

In the Benjamin Franklin High School, now under construction at 116th St. and East River Drive, New York City, new type chords were used to decrease the cost of welded trusses; an effective system of control was used to assure that the many field-welded joints and beam-connections of various types would be made in accordance with the approved details; and welded built-up girders support column loads and heavy beam reactions. These are some of the features that characterize this large structure whose specifications permitted either riveting or welding and whose design plans for bidding contained both riveted and welded details acceptable to the engineers of the board of education. The low bid on the 2,600 tons of steel required was on the welded option.

What is believed to be a new concept was used by the Lehigh Structural Steel Co. in detailing and fabricating six 13-ton ceiling trusses to span the 79-ft. width of the auditorium as well as seven similar trusses over the main gymnasium. These trusses are of Warren type and about 6 ft. deep (Fig. 1). Each truss carries an exterior column at a point 22½ ft. from one end, there being a setback in the front face of the building.

Fig. 2. Sketch indicating small amount of waste involved in making the chord sections shown in Fig. 1.

The unusual feature is the manner in which the chords were made by splitting 36 and 33-in. wide flange beams along joggled lines, so that when the resulting two parts of a beam are separated and spread apart, they form top and bottom T-section chord members with an increased depth of stem for web member connections at the panel points, which, of course, are staggered in a Warren truss. Most of the gas cut lines are common to both of the pieces thus formed and there is only a small amount of waste material (Fig. 2): even this would not have to be removed in cases where clearances, appearance, and dead load weight are not important considerations. This

system of fabricating the chords proved to be very economical.

The web members of the trusses range in size up to 8 x 6-in. angles. At the supports, the chord members are welded directly to column webs.

Balcony framing

The balcony in the auditorium is carried by five main cantilever girders about 40 ft. long and of 5-ft. maximum depth, built up from flange plates fillet welded to web plates. Each flange is reinforced with one coverplate, as in the case for all plate girder members involved in the project; it seldom proves economical in welded construction to use more than one coverplate per flange.

Four of these main girders (Fig. 3) are paired, one on each side of a column and joined together transversely with tieplates. Connections to the column flanges are made with fillet welds around slots in the girder webs. The last of the five girders rests on the top of a short column. The maximum computed uplift at the rear end of this girder is 78 kips; and that for each of the other four girders is about 62 kips. These negative reactions are taken by columns in a line not yet erected when the Fig. 3 photo was taken. Intermediate balcony girders receive their main support from a line of shallow heavy truss bridging that frames between the main girders and transfers the loads to them.

Because of the variable depth and cross-section of the main girders, and the concentrated loads that are transferred to them from the bridging trusses, the longitudinal shear had to be carefully computed at various points of different cross-section to determine the size of the flange-to-web welds. A graphical solution was made by plotting a composite diagram of the varying values for the moment of inertia, static moments of the flanges, and total shear, with the result that the longitudinal shear at any point could be determined readily.

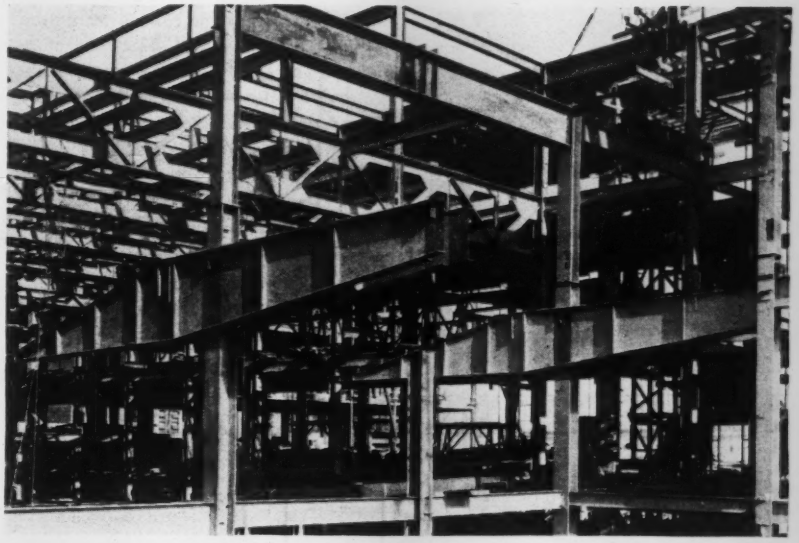


Fig. 3. Welded balcony girders attached to columns by fillet welds in the long vertical slot through their webs.

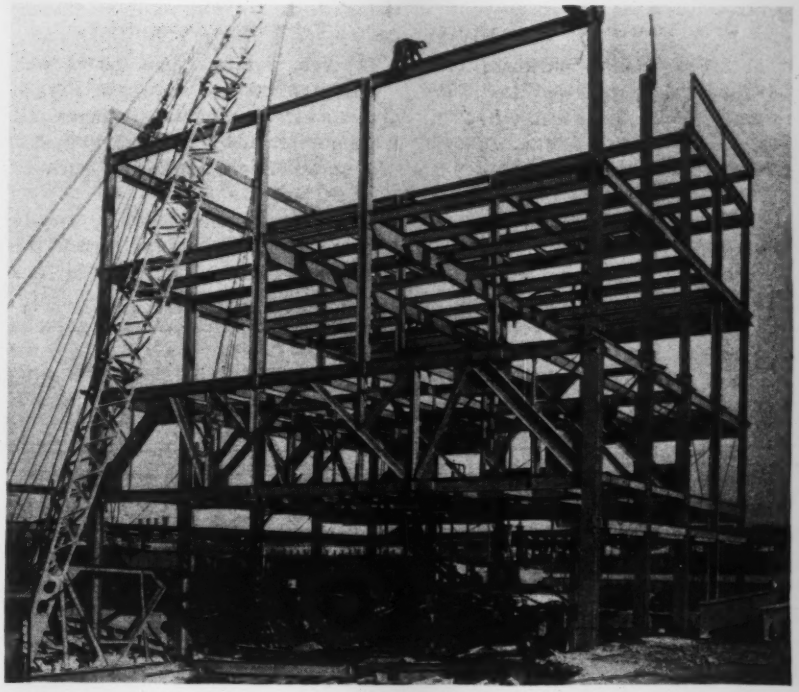


Fig. 4. Full story truss of 58-ft. span, which carries an end-reaction of 515 kips to the column through welds along the edges of the 48x48x1-in. bottom chord gusset plate.

Heavy locker-room trusses

Four heavy trusses of 12½-ft., full-story depth span the 58-ft. width of a second gymnasium in the basement (Fig. 4). There are three locker-room doorways through each truss. Each of the two heaviest trusses weighs 19 tons, carries two intermediate columns, and supports a total of four floors. The maximum end reaction of 515 kips is carried by welding the 48x48x1-in. end gusset plates directly to the column webs. The chords are pairs of 15-in. channels back-to-back, with web reinforcing plates. The diagonal end-post compression members are made of four 8x6x$\frac{5}{8}$-in. angles. Other web members are pairs of angles. These trusses as well as the two lighter ones are of Warren type with sub panel-points at column and floor-beam supports. Gusset plates are used at all panel points, after the fashion of a riveted truss, but they are greatly reduced in area.

Two 9-ton trusses, which alternate with the heavy ones and carry only two floors, are of similar diagram, but for these trusses it proved to be economical to fabricate the chords by splitting 36-in.-wide flange beams in

Fig. 5. Method of splicing tee chord of roof trusses.

the same fashion as for the auditorium and gymnasium trusses, thus eliminating gusset plates at panel points. The 220-kip reactions are carried by welding the chords directly to the column webs.

Other trusses and girders

The library ceiling and third floor are supported by three pairs of Warren trusses 57 ft. long and 4 ft. 9 in. deep, weighing 3½ tons each. In each pair, the trusses are spead about 2 ft. apart to accommodate recessed ceiling light-fixtures. The top chords are T's made by splitting a beam section along a straight line, which in this case provided a sufficient depth of stem to accommodate direct welded connections to the single angle web members. The bottom chord of each truss is a single 8x6-in. angle with the outstanding leg on the outside of the pair, to provide clearance for the lighting fixtures.

At the same third-floor level, a heavy plate girder spans 63 ft. parallel to the span of the library ceiling trusses. In addition to regular floor-beams, this girder, with a maximum end reaction of 340 kips, carries the reactions of two 36-in. wide flange beams that support columns. The girder is made of 16x2-in. flange plates, top and bottom, fillet welded to a 50x$\frac{3}{8}$-in. web. Each flange is reinforced with one 18x1$\frac{7}{8}$-in. coverplate fillet-welded to it. The stiffeners are 6-in. bars, $\frac{3}{8}$ and $\frac{3}{4}$ in. thick.

One floor above, and directly over this girder, is a deeper girder of the same span length, which supports columns at about the third points. Shallow floor joists frame in near the bottom of the web, and the top flange of the girder is supported laterally by large knee-brackets on one side, similar to those of a railway through girder bridge. Each flange is composed of a 16x1½-in. plate fillet-welded to the 64x$\frac{3}{8}$-in. web and reinforced with an 18x1$\frac{1}{8}$-in. coverplate. The maximum reaction of this girder is 273 kips. Like the one below, it is connected to the webs of the supporting columns by means of long fillet-welded connection angles.

Three roof trusses, about 18 ft. deep at the center and 6½ ft. deep at the eaves, span the 57-ft. width of the library wing. Here, again, the scheme of splitting beam sections along a joggled line was used to good advantage to provide T-section chords with ample stem-depth for connections at the panel points. Each truss has two bottom chord field splices made with fillet-welded straps (Fig. 5). A top chord field joint, made with transverse butt-plates fillet-welded together occurs at the ridge.

Column and beam details

Typical column base plates and column splices are shown in Fig. 6. The contractor chose to make all column splices by welding, although the specifications permitted some to be field-bolted.

The beam connections are mostly of the same types as those used in the Air Lines Terminal Building in New York City (*Engineering News-Record*, July 18, 1940). Reactions as great as 200 kips are carried by T-connections, made from split beams, the flange of the T being fillet-welded to the column and its stem field-welded to the beam web along the edge of the stem and along one edge of a slot in the stem.

Some 36-in. 280-lb. wide flange beams that support part of the central tower of the building and other column loads have end reactions as great as 300 kips. Where clearance requirements prevent the use of stiffened beam seats, these very heavy reactions are carried by fillet-welded connection angles, which, however, are smaller than those required for riveted connection angles.

Working drawings

In an efficiently designed welded structure of the type and magnitude of this school building, there are considerably more variations in form and size of structural connections than in riveted work. Therefore, a special scheme was devised for definitely identifying each connection on the job as to details and amount and location of welds.

Along with the preparation of shop details for fabricated members, the fabricator prepared a set of job standards for field connections based upon the minimum requirements of the Board of Education, as given in their welding option. Also, to facili-

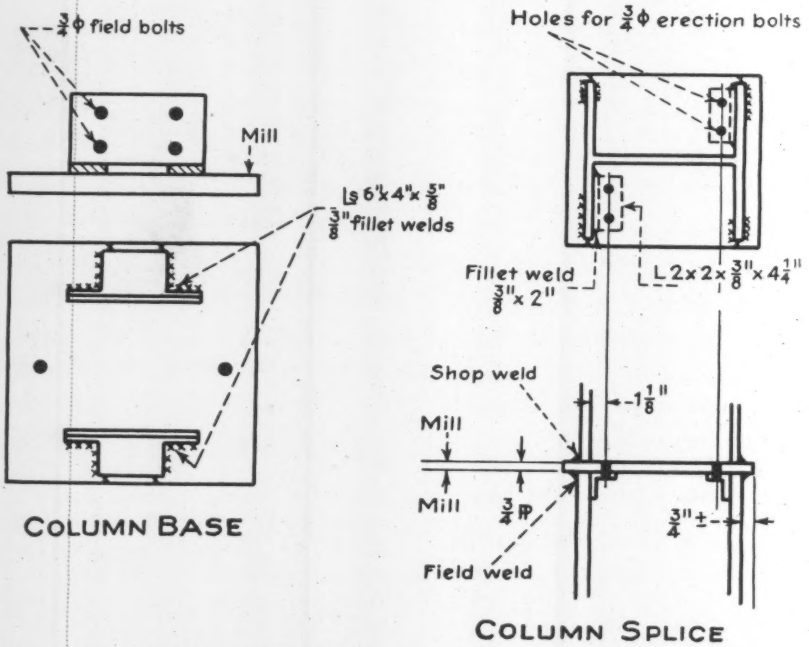


Fig. 6. Typical welded details at the column bases and column splices in the Benjamin Franklin High School.

tate the checking of these framing connections, preliminary column sheets were furnished, which scheduled all the connections and tied them in by reference to the job standards. Simultaneously, erection plans were submitted for checking with the preliminary column sheets. On these erection plans every field-welded connection was marked and referenced to field welding detail sheets that were furnished to the field welding forces and the inspector.

In designing welded beam connections, it is customary to compute the effect of the eccentricity from the face of the connection material to the center of gravity of the welds that join it to the web of the beam. The checking of these connections was greatly facilitated by preparing graphical charts for each type, from which reaction values for any amount and arrangement of welds could be scaled.

Fabrication and erection

The preparation of material for the trusses and girders was done for the most part by oxyacetylene cutting. Where there was sufficient duplication, as in the auditorium and gymnasium trusses, the parts of a truss were assembled on a welding table, aligned largely by means of stop-lugs, and clamped in correct position, after which the parts were tack-welded together. The truss was then removed from the assembly table and the welding completed.

It will be noted that the flange coverplates of the plate girders and of the 79-foot trusses (Fig. 1) were made wider than the flanges. With this arrangement, the weight of the truss or girder can be utilized to maintain close contact with the coverplate while it is joined to the flange by fillet welds made in the horizontal welding position. All the plate girders and trusses, with the exception of the peaked roof-trusses, were completely welded in the shop and each one shipped in a single piece.

The end connections of the heaviest trusses and of the girders were partly welded immediately after their field erection, to take care of temporary loads while erection was completed in their vicinity. Seven single-operator, gas-engine-driven, d.c. welding generators were used for the field welding.

The building was designed by the bureau of construction of the New York City Board of Education (Eric Kebbon, architect, superintendent of School Building Design and Construction; Hans C. T. Toensfeldt, assistant superintendent; A. G. Martens, chief of structural engineering division; H. W. Hoyer, foreman of structural plans for the project; and J. Kalb, designer of the standards and of the arc welding option, with Gilbert D. Fish serving as consultant and furnishing inspection of the welding). Charles Weber is superintendent for Psaty & Fuhrman, Inc., general contractor. The steel was fabricated by the Lehigh Structural Steel Co., Allentown, Pa. (Wm. H. Mohr, plant manager and George Neumann, superintendent). The steel was erected by the Lehigh Construction Co. (W. A. Gardner, manager of construction, Norman Ferguson, foreman, and Richard Miller was in charge of the welding operations).

Precast Concrete Ribs Repair Tunnel Roof

REPAIR of the dangerously defective roof of a tunnel on the Madras & Southern Mahratta Ry. in India was facilitated by the fact that although the tunnel had been built for double track, only a single track had been laid and could be shifted to accommodate the reconstruction work. For the same reason, the new permanent work could encroach upon the original clearance limits. This tunnel, 1,350 ft. long, had a brick lining, with roof arch 3 ft. thick and 14-ft. radius. When serious cracking was found in this roof, timber falsework was placed for temporary safety, and trains were restricted to a speed of 5 mph. The following description of the repair work is condensed from a paper by J. Sitaram in the 1940 "Proceedings" of the Permanent Way Institution (London).

The method decided upon was to place a series of precast concrete ribs under the brick arch, each rib 18 in. square in section and 20 ft. 6 in. in span. They were placed practically in contact with each other. The load was then to be transferred to these ribs, thus permitting removal of the temporary falsework.

The ribs were built on a casting platform outside the tunnel, using a stone concrete, 1:2¼:4 mix with a permissible slump of only 1¾ in. Reinforcing consisted of steel rods and wire mesh. A few ribs were cured by immersion but most were cured under wet burlap, 25 days being allowed. While the ribs were being made, side walls of granite blocks laid in cement were built inside the old brick walls, leaving a clear width of 18 ft. 9 in. at rail level. Upon these concrete walls the new concrete skewback blocks were placed for each rib in turn.

After some experimenting in handling and erecting the 10-ton ribs, the plan adopted was to place the rib astride a saddle built at the end of the boom of a 20-ton wrecking crane, wood packing being placed on the saddle to conform to the curve of the rib. The boom was then swung parallel with the track and, in this position, the locomotive hauled the crane into the tunnel.

When nearly in position, the boom raised the rib to clear the new concrete skewbacks. Then the engine was cut off and the crane was inched into exact position by pinch bars, so that the rib could be lowered onto the skewbacks. Wedges were provided in four places between the rib and the old arch to keep the rib firmly in position until the back packing was done.

A 1:2 mixture of wet sand and ¾-in. stone was packed over each rib by rammers, working upward from each skewback. Grouting pipes 1½ in. in diameter were inserted temporarily in this packing at intervals of 3 ft. and neat cement grout was pumped in, the bottoms of the joints between ribs being calked with burlap. After the grouting, the pipes and burlap were removed and the joints were finally pointed with cement. In the average daily progress, two ribs were placed and grouted. The track originally placed at one side was relaid on the center line of the tunnel.

General grouping of buildings at Camp Edwards, Falmouth, Mass.

Handling a 20,000-Man Crew on a Camp Job

***Contents in Brief**—In constructing Camp Edwards, a $28,500,000 camp for 30,000 trainees on Cape Cod, the huge labor force was divided into autonomous crews, who handled definite jobs in definite areas. Material delivery was direct to each of these areas. Timekeeping and paying were decentralized, although records were kept in the central office. Special working drawings were made for each crew.*

IN 125 WORKING DAYS after construction was started Sept. 12, housing and facilities at Camp Edwards, on the inner end of Cape Cod peninsula near Falmouth, Mass., were ready for 30,000 troops. Involved were over 1,400 buildings, water supply and sewage disposal plants, 74 miles of underground water and sewer lines, 30 miles of roads, 11 miles of railroad tracks and large surfaced areas for truck storage. How it was done is the familiar story of good organization, construction ingenuity and high-pressure work. But the details are suggestive and instructive.

Camp Edwards is located on the southeast corner of a 19-sq.mi. military reservation, on a level plain bordered by rough terrain covered with a scrub pine forest. The general layout of the camp provided for eight rows of buildings on each of the four sides of a mile-square parade ground, with outlying areas reserved for the hospital group, quartermaster's depot, corps area service command, bakery, cold storage plant, sewage disposal plant and garbage incinerator.

All buildings follow the standards developed by the Army, based on barracks for 63 men, or half a company. Six buildings completed the company group—three barracks, a mess hall, a storehouse and a recreation building. Six company units are placed together to form a regiment group, which includes (in addition to the company buildings) headquarters administration building, infirmary, barracks for the headquarters company, regimental cold storage building, truck garage and firehouse. Regimental groups are separated from each other by 250-ft. open strips as a fire break (*ENR*, Oct. 24, 1940, p. 539).

A quick concept of the size of the project can be obtained from a brief statement of the major quantities involved.

MATERIALS REQUIRED

63,000,000	b. ft. (more than 2,000 cars) of lumber
5,000,000	sq. ft. of fiberboard
85,000	rolls of roofing and sheathing paper
26,000	kegs of nails
64,000	yards of concrete
1,000,000	yards of earth moved
20,000	workmen employed of whom more than 10,000 were working as carpenters

Walsh Construction Co., the contractor and Charles T. Main, Inc., the engineers, both had organizations experienced in large-scale construction work. Supervisory personnel was, therefore, easily provided. The real problem arose in securing 20,000 workmen for a job located some 50 miles from a large city (Boston or Providence) and with train and bus service only moderately good and roads only fair. A survey made of the entire territory from which the camp might expect to draw skilled labor, with allowances made for labor for other nearby defense jobs, notably Camp Devens, Mass., and the Naval Air Station at Quonset, R. I., indicated that a sufficient number of men could be obtained who were within daily driving distance of the camp or who could find homes at the resort hotels and housing facilities seldom used except during the summer season. Advertisements inserted in the newspapers within a 50-mile radius and contacts made with all union organizations finally rounded up the necessary force, most of whom came by bus (a service which was greatly improved as it became necessary) and in individual automobiles. The resulting traffic condition became a serious problem, but this difficulty was partly alleviated by establishing a uniformed police force and designating many roads for one-way traffic at the time shifts were changing.

Under a project manager and construction managers for superstructure and subsurface work, more than thirty "group superintendents" directed the work of separate crews, any one of which would have constituted a complete field organization for a moderate sized project. Each group superintendent was assigned a definite job in a particular area and operated much as if he were miles away from the other parts of the work. The larger groups had from one to nine assistant superintendents and some had as many as 45 foremen, each in charge of a crew averaging about 15 men. Each group superintendent had his own trucks, his own checking office and timekeepers, and had full responsibility for the progress of the work in his area.

Daily at 4:30 p.m., the end of the day shift, all group superintendents and subcontractors' superintendents on superstructure work met with the construction manager and the day's operations were reviewed and the next day's program carefully planned. Requsitions were made at that time for the material and workmen needed for the following day.

Hiring of all new employees and reallocation to different work was done through a central office near the entrance to the job. The group superintendent's requests for added men was the criterion for hiring; reassigned or newly employed men gathered around their group superintendent's name standard at the central office and were picked up there by the group truck for transfer to the new assignment.

The central office was used for record work and handling of payrolls, although a portable checking booth and timekeeper were assigned to each construction group. In this way an employee's time did not start until he was in the area where he was assigned to work.

During the peak of construction the payrolls amounted to almost $1,000,000 weekly, paid in cash every Thursday. Payrolls closed on Saturday night allowing four days for records to be prepared and forwarded to an armored car service in Boston which brought the money to the job. The armored motor trucks, with guards were used as pay cars, traveling about the site where each group superintendent was working. Workmen came to the car as it stopped in their area, taking a minimum of time from the work.

Materials

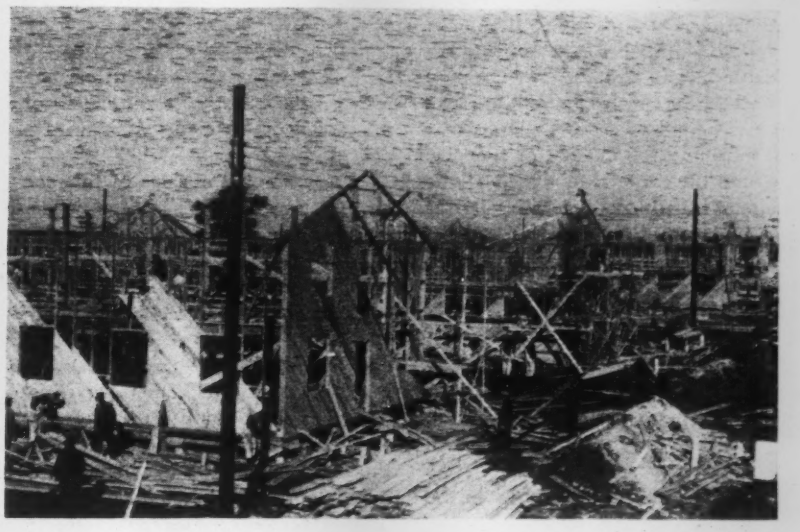
Most of the construction material moved to Camp Edwards by rail, making it necessary to provide facilities for handling at least 100 cars daily. A study of rail facilities indicated the nearest location available for development into a yard of the required size was Sagamore, Mass., about an 11-mile haul from the camp. The unusual length of the haul was considered secondary in importance to the adequacy of the yard, and existing facilities were quickly extended, largely by forces of the New York, New Haven and Hartford R.R. to accommodate all the cars required.

Even before the engineers and contractors were designated, 33,000,000 b. ft. of lumber was ordered by the Army and was arriving by the time the contractors reached the site. The engineering forces, starting at the same time, were obliged to stake out the building sites with great speed so that the lumber could be delivered in one handling to its final destination. Occasionally confusion resulted, but rather than move the lumber a particular building was skipped until adjacent buildings used up the lumber piled on its site.

All incoming material was routed over one road only, along which booths were established for the checkers. Truck drivers were instructed by the checkers as to the area in which the material was to be unloaded, in accordance with the daily requisitions of the group superintendents. This plan worked well, especially on the 30,000,000 b. ft. of additional lumber that it was necessary to order, which came in as required for construction. Lumber ordered, after the initial 33,000,000 b. ft., was purchased under competitive bids from several firms, with the requirement that the lumber must already be on cars and in transit so that car numbers were available for speedy reference and tracing.

Power post auger digs foundation holes 18 in. in diameter. This procedure in the construction of footings.

Sidewalls of all buildings were framed lying flat on the first floor. For one-story buildings the frames were sheathed before erection but on two-story structures they were sheathed after raising to position.



Materials requisitioned from the central yard were assembled during the night and early morning for delivery early in the day to the group superintendent who had requested them.

Working drawings

The plans followed the standard U. S. Army drawings and, to facilitate and coordinate the work in the field, the contractor engaged a force of fifteen draftsmen to prepare detailed working drawings relating to each independent operation. These were prepared on sheets 24 x 36 in. and were similar in purpose and makeup to a steel fabricator's shop drawings, but with less detail on individual sheets. Each sheet contained all the information relating to a specific minor portion of the work, such as the footing or framing detail for a single type of building.

Foundations were prepared on a three-shift, 24-hr.-a-day basis, so that framing of the building superstructure was never delayed. Footings were about 4 ft. deep, to get below frost action, and rest on a good sand base. Construction above the foundations was done only in daylight hours.

Stovepipe pier forms

Original design of most building supports was an 8 x 8-in. concrete pier on a 16 x 16-in. footing. A suggested change in this detail was approved making it possible to use large-size power-driven post augers to produce a round hole of the equivalent footing area, which was filled with concrete to within a few inches of the ground surface. To form the pier above this level a 26-in.-long section of standard black 8-in. dia. stovepipe, shipped to the job nested, was used. The bottom of the pipe was set in the fresh concrete and the top was nailed to a 2 x 4 runner that was set along the outside of the pier line with the top at exact grade. This eliminated costly wood forming, stripping and backfilling, and the alignment method was so simple that a tremendous saving was effected in time and dollar costs. Concrete was delivered in truck-mixers.

From the start to the finish of the job each group superintendent built only one type of building and within his organization each crew always performed the same operation. As soon as the concrete hardened in the foundation the first floor deck was

Square termite shields cap round columns formed by 8-in. stovepipe.

constructed, keeping well in advance of crews working on frames. The walls of all buildings were framed flat on a working platform, and in the case of one-story buildings they were sheathed and then raised to position; frames for the two-story buildings were built in panels and raised in advance of sheathing. On a record day, 69 "balloons," or building frames, were erected.

A succeeding crew placed interior posts and second-floor joists, with others following for rough sheathing, roofings, wall sidings, etc. In general, all of the framing and cutting of lumber was done at the individual buildings as required, no power equipment being used since building construction preceded the installation of power lines. No pre-cutting of framing lumber was attempted.

The only materials coming to the job prefabricated were the doors, windows and frames.

In retrospect

Some personal reminiscences of D. G. Aronberg, construction manager on the building erection; throw interesting light on the difficulties of the job:

"Time was the essence of this contract. Ours was one of the largest camp contracts let on a cost-plus-fixed-fee basis—and one of the first. When the Army terminated the contract on March 8, 1941, all of the buildings were 100 percent complete and accepted. The total cost was approximately $28,500,000, more buildings and facilities being constructed than originally contemplated. Illustrative of the scope of the additional work, the 33,000,000 b. ft. of lumber ordered by the Army for the original work was used up in 80 calendar days and 30,000,000 b. ft. of additional lumber was purchased. Despite this increase in the volume of the work, our organization functioned smoothly.

"As was the case in 1917-18, the carrying out of a large cantonment program in an emergency offers plenty of opportunity for 'second-guessing' after the job is done, but the record will show that the contractors, the constructing quartermasters and their technical advisers did a good job under tremendous difficulties. The supply of skilled construction workers was not equal to the demands made by a national program of such magnitude and some inefficiency must be expected when, as at Camp Edwards, some 20,000 men are hurriedly brought together to do a $28,500,000 job in 125 working days. It is true that many of the workers who claimed mechanical skill turned out to be rank amateurs. But it is equally true that, except for a few isolated cases, everybody entered into the spirit of an emergency defense project and made an honest effort to do a day's work. Instead of apologizing for the fact that many of our 10,000 so-called skilled mechanics were not skilled, it seems permissible to stress the fact that, anticipating this, simple framing drawings were provided that enabled building the camp on time with a high percentage of unskilled workers; and if, as has been stated, a former waiter turned out to be one of the top foremen, it is rather gratifying to know that a great many unskilled men were made passable mechanics for future emergency projects."

Personnel

At Camp Edwards, Major H. Algeo, Captain K. M. Pattee and Captain F. E. Robbins successively acted as constructing quartermasters. For Charles T. Main, Inc., engineers of Boston, Frank Gunby was in charge. For Walsh Construction Co., C. D. Riddle was job manager during the major construction period, followed by H. H. Dugan; D. G. Aronberg managed the building construction; and T. J. Walsh, Jr., and J. E. Small were in charge of foundations and utilities. Principal subcontractors were Fischback & Moore, Inc., New York City, electrical work; Raisler Corp., New York City, heating; and M. Ahern Co., Boston, plumbing.

How a Cellular Concrete Bridge Acts Under Traffic

F. W. Panhorst

Bridge Engineer, California State Division of Highways
Sacramento, Calif.

***Contents in Brief**—Girder bridge at Santa Paula, Calif., has a 120-ft. clear span and counterweighted abutments that reduce moments to one-quarter of usual amount. In service a year, the bridge, which has a relatively low stiffness by virtue of its long span and shallow depth, exhibits deflections to no greater degree than expected. Live load vibration is distinctly apparent but amplitudes are small. Measurements are continuing as part of California policy to collect service data on all important concrete structures.*

A BRIDGE across Santa Paula Creek at Santa Paula, Calif., completed in June, 1940, is an outstanding example of the applicability of the cellular type of reinforced concrete design to locations where headroom is limited. Since the structure has been in use for almost a year it is possible to observe its action under traffic.

The bridge replaced an old through truss structure which was moved to one side and used as a detour during construction. It is designed for an H-15 loading with a clear span of 120 ft. and two 25-ft. roadways divided by a 4-ft. raised separation strip. Two 4-ft. sidewalks with integral curb and gutter make the over-all width 62 ft.

Inasmuch as the bridge had to fit the established grade of contiguous streets and provide a clear span with maximum vertical clearance, a design was sought which would clear the high-water mark, which was only 2 ft. below street grade. It also had to be attractive and reasonable in cost. Of the various designs studied the cellular concrete type was decided upon. This design made it possible to decrease the depth of the span by reduction of the dead load, which was still further reduced by the use of light-weight aggregate specified not to exceed 110 lb. per cu. ft.

Counterweighted abutments

The ordinary use of cellular, or hollow, box construction is not particularly new or outstanding, but in this case the design employed an unusual and interesting application of restraining end moments to relieve the center span moments. The abutments at each end are so designed that they continually exert a very large counterbalancing end moment into the girders. Such end restraint, or fixed end moment, induced by the counterweighted abutments(Fig. 2) reduced the normal simple span dead load and live load moments from approximately 33,500,000 ft.-lb. to 8,500,000 ft.-lb. In effect, the simple span moments have been reduced to about one-quarter of their normal amount.

The superstructure of the bridge is composed of a series of eleven flanged ribs or girders varied in depth from 2 ft. 9 in. at the center of the span to 4 ft. 3 in. at the abutments. The ribs also vary in web thickness from 1 ft. 2 in. at the center to 2 ft. at the abutments and are spaced 6 ft. 4½ in. center to center. The top slab which is constructed integral with the ribs is 7 in. thick and the bottom slab varies in thickness from 6 in. at the center of the span to 1 ft. 4 in. at the abutment.

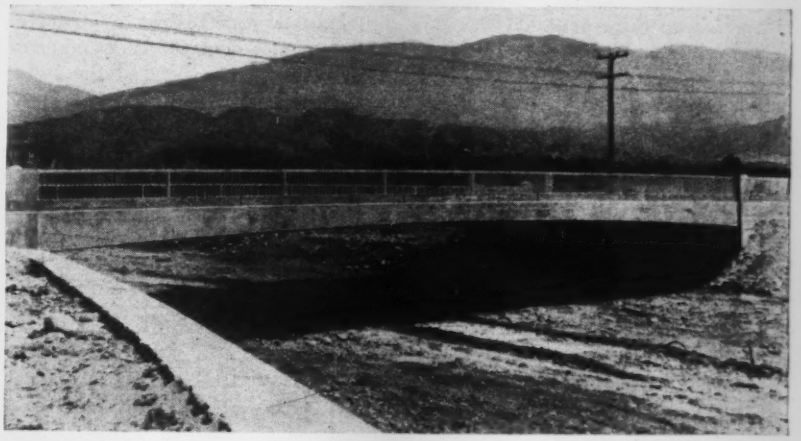


Fig. 1. Existing street grades and high water elevation dictated a shallow deck for this cellular girder concrete bridge at Santa Paula, Calif.

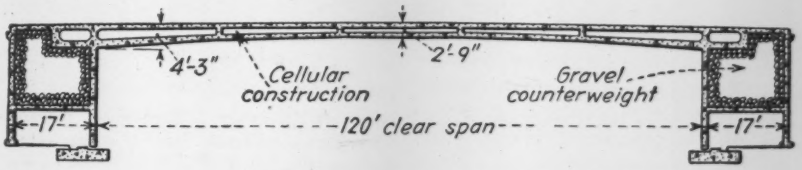


Fig. 2. By using counterweighted abutments the simple span moments in this cellular girder bridge were reduced to one-quarter of normal.

Details of the design are shown in Fig. 3. It will be noticed that the reinforcement in the top of the deck over and adjacent to the abutments is spread out into the slab. This places the steel where it can assist the slab in taking stresses which the slab otherwise must take alone or fail; experience has shown that this method of reinforcement is entirely satisfactory. At midspan it will be seen that the tension bars are not distributed the entire distance between rib webs, but are discontinued just outside the webs; this is somewhat at variance with other designs of cellular type construction.

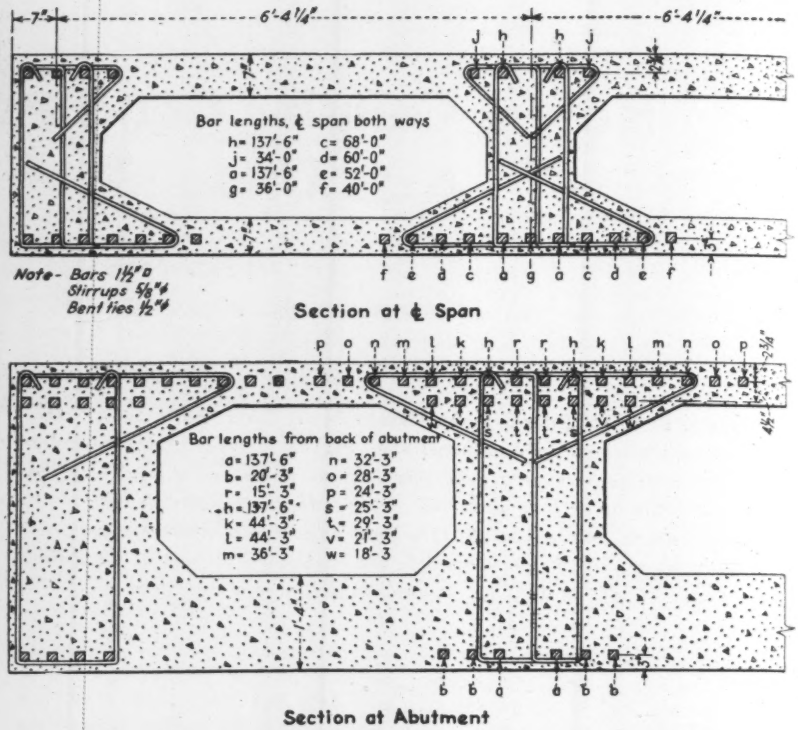


Fig. 3. Reinforcing steel layout in Santa Paula Bridge. Note extra reinforcing in top of deck over the abutments to strengthen the slab.

Deflection measurements

Realizing that the type of structure and the conditions under which it was being used were somewhat unusual, the California division of highways thought it advisable to keep a record of the movement of the superstructure, and for this purpose brass reference plugs were set in the deck during construction. Three lines of plugs were set, one at each curb and one about 2 ft. to the right of the centerline of the bridge. When the concrete was at least 30 days old, levels showed that there had been no settlement of the falsework. Zero-load levels were run on all reference marks. Then the centering was struck and dead load levels run, showing initial midspan deflections of 0.083 ft. near the centerline and 0.100 ft. at the curb lines. Although all levels were run from a benchmark independent of the structure, the computed deflections are referred to the reference points over supports, to show the relative changes between the deck and its supports. Fig. 4 shows the deflections at midspan (after the initial deflection that occurred when the centering was struck), as observed up to April 16, 1940. The computed deflection under dead load is $1\frac{7}{8}$ in. or 0.157 ft. based on $E = 2{,}250{,}000$ for concrete in compression and with no allowance for concrete in tension.

It might be pointed out that the 0.05 ft. deflection between April 18 and May 17 simply represents the position of the slab approximately one month after centering was removed. No attempt is made to theorize on the reasons for the magnitudes of any of the deflections noted or the relative changes which occurred. There may be a question in the minds of some readers as to whether subsequent additions of hand rail, center dividing strip, etc., placed after the centering was struck, could materially affect this reading. However, the additional weight thus placed was relatively small and is counterbalanced to some extent by removal of forms and contractor's equipment and by the drying out of the lightweight concrete.

The deflection and vibration of the bridge is quite noticeable when it is crossed by heavy trucks, particularly to a person standing at the center of the span. In order to study this condition in a general way, a deflection gage was securely fastened to the upstream side of the bridge at midspan. This gage consisted of a timber push rod coupled to a 1:10 level arm pointer, all supported by a 2 x 4-in. timber stake. The bearings consisted of 20*d* nails fitted snugly in drilled holes. The maximum observed displacement of the pointer was 0.104 ft., and this occurred under a heavy oil tank combination vehicle on the lane nearest the gage. This represented an actual deflection under the load at the center of the span of about 0.010 ft. It was found that the gage gave quite accurate results and would consistently indicate a displacement of the pointer of as little as 0.005 ft., which represented a deflection of 0.0005 ft.

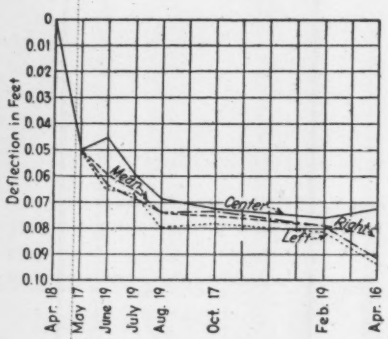


Fig. 4. Midspan deflection record measured on three lines of gage points across the deck. The zero point represents the initial deflection under dead load of the slab.

The deflection gage was also used to measure vibration of the span under live load. Although, to a person standing on the span, the structure felt as if it vibrated considerably under heavy loads, the amplitude of the vibrations was very much less than they were thought to be. The maximum positive amplitude read on the pointer was about 0.01 ft., corresponding to a double amplitude of 0.002 ft. for the slab at midspan. The observed frequency was 3 cycles per

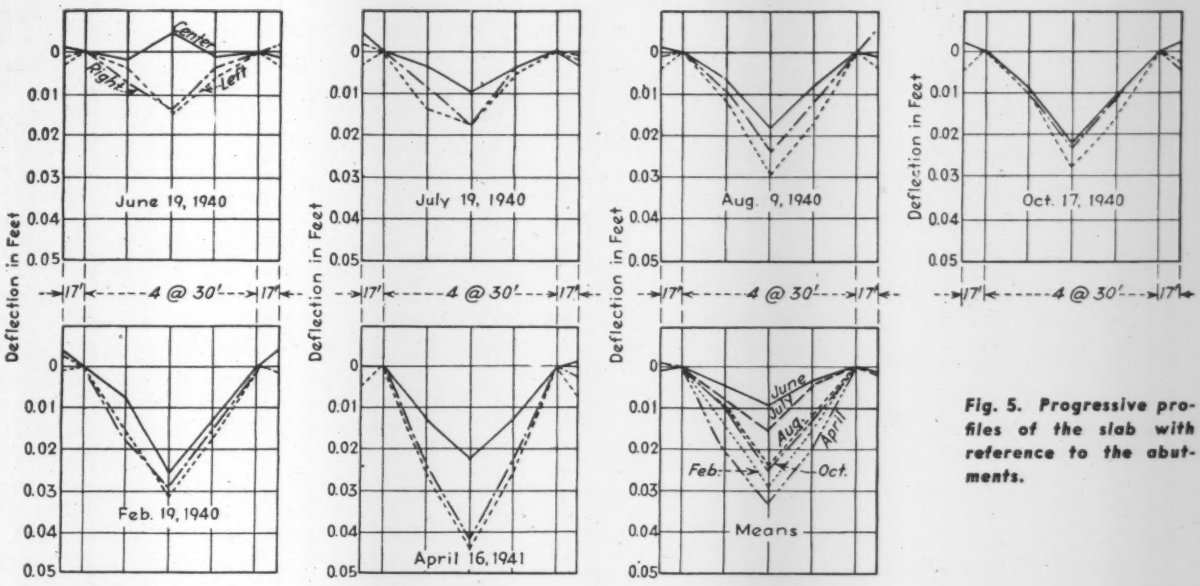


Fig. 5. Progressive profiles of the slab with reference to the abutments.

sec. and the damping time to the point where vibrations were imperceptible on the gage was about 17 sec.—or through about 50 cycles. The vibration of the span under light cars is negligible.

So far the records indicate that the deflection of the structure is no more than expected in a span of such relatively low stiffness. It is not practical to draw any definite conclusions from the results, and it should be realized that the recorded movements are small, so that possible instrumental errors or movements due to shrinkage and temperature may be relatively large.

Only through a study of many cases of concrete bridge construction can it be hoped that exact information leading to more accurate design in the future can be obtained. The state of California is carrying out a program of collecting such information on the major concrete structures built by it during recent years. It is hoped that in time this will aid in solving some of the present problems connected with this kind of bridge.

The bridge was designed by the bridge department of the division of highways of the state of California, and constructed under contract by Byerts and Dunn. C. H. Purcell is state highway engineer and Ernest Aeppli designed the structure. H. E. Spickemire was resident engineer.

The total contract price for the bridge was $82,617.50, which included the cost of paving the approaches and incidental work. The cost of the bridge alone was $58,379.00, the unit prices being given in the accompanying table.

UNIT PRICES, SANTA PAULA BRIDGE

		Bid Price	Amount
459,400 lb.	Bar steel	.035	$16,079.00
120 s.y.	Wire mesh	.30	36.00
920 c.y.	Class "A" concrete (in abutments)	16.00	14,720.00
730 c.y.	Lightweight concrete	27.00	19,710.00
2,730 c.y.	Excavation	2.00	5,460.00
239 l.f.	Steel rail	6.00	1,434.00
800 c.y.	Ballast	.55	440.00
	Miscellaneous	.....	2,000.00

Warsaw's Water Plant Destroyed

THE RELATIVELY NEW American-type water filtration plant installed at Warsaw, Poland—said to be the largest in Europe—was destroyed by German bombing, according to information received by M. N. Baker, associate editor, retired, of *Engineering News-Record*. This is one of the first accounts of waterworks damage to reach this country. Mr. Baker states:

"In answer to a query as to the fate of the water filters at Warsaw during the *blitzkrieg* of 1939, Stefan de Ropp, Director Polish Information Center, New York City, wrote to me on April 21, 1941:

" 'Yes, the water filters serving the city of Warsaw, which may well have been considered the pride of that luckless capital, were destroyed by bombing. It is obvious that their repair cannot be undertaken until the end of the war. The State Institute of Hygiene in Warsaw was dissolved by Germans, and I have not heard just what has become of Mr. A. Szniolis, Chief of the Department of Sanitary Engineering.' "

It is pointed out by Mr. Baker that the Warsaw filters were installed in 1932–33 by the Jewell Export Filter Co. of Providence, R. I. The plant consisted of 16 units of mechanical filters with a normal rated total capacity of 72 mgd. (U. S.). The specifications state that the filters were to be supplied from an existing settling basin, which ultimately would be converted into a coagulation basin, and that the product of the mechanical filters would be delivered either to the existing slow sand filters or to the settling basin built many years ago. When completed, in 1933, it was the largest rapid filter in Europe.

From a tabulation of data sent to Mr. Baker on Jan. 13, 1937, by Mr. Szniolis, it appears that the water supply of Warsaw was then being settled, filtered through both rapid and slow sand filters and chlorinated. The population of the city was given as 1,200,000. At that time Poland had 170 waterworks in use and about 40 under construction. Most of the works supplied groundwater. There were about 45 iron removal plants employing aeration and filtration, says Mr. Baker.

British Road and Rail Experience in War

***Contents in Brief**—Highway and railway transportation in England under war conditions as seen by Lt. Col. L. V. Murrow, state highway director of Washington, are the subject of a report to the Public Roads Administration that has been made public by the Roads Committee of the Senate. A summary of Col. Murrow's report is given in the following, significant sections being quoted in full.*

ADEQUATE TRANSPORTATION has been one of the greatest single factors in modern warfare, both offensive and defensive. Contrary to official theories, highway transport is more efficient under war conditions than rail haulage, having greater flexibility under emergency and being less vulnerable to air attack. These conclusions among others are brought back from Britain by Lt. Col. Lacey V. Murrow, highway director of the state of Washington and now on leave for service in the Air Corps. Sent to England at the request of the Federal Works Agency, to study and report on highway and railway transportation there under war conditions, as an aid to the Public Roads Administration in developing its highway transportation plans for defense purposes, Col. Murrow submitted a report to Thomas H. MacDonald, commissioner, Public Roads Administration, which report was made public last week by the Roads Committee of the Senate.

British transportation

"Both railroad and highway systems," says Col. Murrow, "were laid out and established with London as the hub, London and the southeastern channel ports having been the principal points of both import and export trade. Britain lives by her ships, yet for several months past it has been difficult to carry on even coastwise shipping destined for the London area. The result of this change in the center of gravity of transportation and distributing activity to the western ports has thrown the transportation systems out of balance. These systems under present conditions are operating in reverse direction to the movement for which they were designed and built. This is particularly true with reference to the railroads. . . . Prior to the war the great tonnage item of coal was largely moved from the mines to principal metropolitan areas by coastwise steamers and was then distributed locally by railroads, trucks and horse-drawn vehicles. It is now necessary that a large percentage of coal be moved from mine to consumer by rail.

Effect of aerial bombardment

"In general, it can be said that railways are much more vulnerable to damage and delay caused by aerial bombardment than are highways. One small bomb has, in some instances, disrupted the block signal system and caused several hours' delay in train operation.

"Bomb damage to both highways and railways has been surprisingly low. It was observed that the largest amount of material damage done to railway property thus far has been the partial destruction of the terminals in the larger cities. A number of both highway and railway bridges have received direct hits, most of which did little damage. Investigation of a number of these bridges would indicate that in most instances the bomb passed completely through the deck and generally exploded in the water or mud beneath, resulting in very little damage.

"Damage to rural highways usually causes very little delay. The craters are either quickly filled or a suitable detour is provided.

"An entirely different problem is presented in the bombing of city streets. Beneath the streets, as in our own country, there is a great number of water mains and laterals, sewers, gas mains, electric and telephone conduits. A direct hit on the street results in much more damage than the actual damage to the street surface."

Highway transport

According to British, French and Belgian officers with whom he talked, transportation facilities have been of greatest importance. In France the German army made full use of the entire road net, and it is stated by air observers that little or no cross-country movement of tanks or other mechanized units occurred. Every detail of movement, supply and maintenance had been worked out in advance with the result that there was no confusion behind the German lines, while Allied traffic was continuously snarled.

"Highway transportation in the zone of operation is extremely important for two primary reasons: first, because of its great flexibility, and second, because it is least vulnerable to aerial bombardment. Officials in the Ministry of Transport, who have for years relied upon and believed implicitly that railroad transport was of primary consideration and who were at the same time at least partially responsible for starving motor transport of its proper expenditures and improvements, now have no hesitancy in stating that they sincerely regret that motor transport was not given due and proper consideration in the matter of facilities and developments.

"For a number of years Britain has been expending only about 35 percent of the taxes levied and collected for highway purposes on the highway system. The balance of this revenue has been diverted for purposes of schools, old age pensions, and other items." The funds spent on highways have been spent primarily on strengthening and improving the existing roads which are narrow, crooked, and in many instances have excessive grades. At present there is a serious lack of roadbuilding and maintenance equipment due principally to the loss of much equipment in France, to diversion of road equipment to the construction and maintenance of roads to air fields, and to the use of road equipment in removing debris resulting from bombing.

Great Britain has a public highway system of 180,000 miles, including rural highways and city streets, or approximately 2½ miles per square mile of area. Because the construction, maintenance and operation of this system is the responsibility of over 1,300 separate agencies there is a se-

rious lack of uniformity as to location, construction and maintenance standards.

There has been no attempt to create a marking system similar to our own federally-numbered system, and before the war there was a serious lack of directional signs. This has now been made worse by the removal of all directional signs and even the names on railroad stations, post offices and banks as a defense measure.

"Travel by motor vehicle is further complicated at present by the rationing of gasoline. The average automobile owner in England today can secure enough gasoline to operate his car a distance of about 150 miles per month, irrespective of whether a car operates on 15 miles per gallon or on 40 miles per gallon. . . . There appears to be no lack of sufficient quantity and quality of gasoline and lubricating oils for all necessary military purposes. In anticipation of the probable shortage of gasoline under wartime conditions, the British government has offered a sort of prize or subsidy to operators who will use in all or part of their vehicles some kind of locally manufactured substitute for gasoline."

Still some traffic problems

"Prior to the war the motor-vehicle registration was about one for each 23 persons, or a total of about 2,000,000. At present this registration has dropped to 1,215,000 due to rationing of gasoline, turning over vehicles to the military, lack of spare parts and production. . . . It is interesting to note, however, that a few short-period traffic counts indicate that, even with the reduced registration, at peak hours the traffic density is almost as great on certain arterials as it was prior to the war. The peak periods are shorter and can perhaps be accounted for by the rush of traffic attempting to reach its destination before blackout time.

"The control of traffic in the metropolitan areas is still accomplished by the usual method of police direction and traffic signals. However, it has been found necessary under blackout conditions to restrict the red, green and amber lights by covering the lens with opaque paint. The only light that is permitted to penetrate the lens is that through a horizontal and a vertical line extending in both directions across the entire surface. The width of these lines is about one-quarter of an inch and when the lights are operated at night it gives the appearance of a red, green or amber cross of the dimensions above indicated. . . . The accident rate has materially increased since war was declared. This increase can quite properly be traced to the increase in fast-moving military traffic and to the blackout."

Organizing highway transport

Col. Murrow states that considerable study has recently been given to the control and operation of the highway system and that the Minister of Transport has laid out a system of strategic "red" and tactical "blue" highways of 13,800 miles somewhat similar to our own strategic highway system; but due to the urgency of their present situation, the British system has been somewhat further advanced in some respects than ours. At any time the military authorities can take full control of this system, including policing, and can exclude it from all forms of civilian traffic. Provision has been made, however, for the issuance of windshield stickers (which have already been printed) to certain types of emergency vehicles such as ambulances, fire trucks and cars belonging to civilian medical personnel.

"In the areas that are considered to be most vulnerable in an attempted invasion, a carefully worked out scheme for the movement of civilians now residing in those areas has been completed. This plan provides for the evacuation of civilians over roads not forming a part of the strategic or tactical systems. In all instances where it may be necessary for the civilian traffic to cross either the red or blue network, the points at which the military will be interrupted in order to permit this movement have been determined.

"In anticipation of probable bomb damage to the strategic and tactical systems, the Ministry of Transport has purchased and stored at intervals of 10 to 15 miles supplies of materials necessary for quick and adequate repairs. They have also stored at important points standard prefabricated temporary bridges."

Some study and a considerable amount of work have been done on methods for blocking the roads, and various types of obstructions against the landing of aircraft have been placed in open fields and on highway tangents. Cables stretched about 25 ft. above the ground are used for this latter purpose and were found to be quite effective in two instances in which planes attempted to make a forced landing.

In addition to the road blocks, highways and bridges have been mined at strategic points.

In his conclusions Col. Murrow stresses the need for proper advance planning such as was inaugurated in the 1935 survey of the Public Roads Administration and urges the extension of that work to include such things as an inventory of available motor transportation and construction equipment, together with the abilities of manufacturers to produce additional units, under wartime conditions if necessary. Highway transportation facilities, he states, should be improved just as rapidly as possible. "This statement is particularly true with reference to the bottlenecks now existing on the strategic system, and the construction of necessary access roads to military and defense manufacturing establishments. Highway transportation, because it is the most flexible and least subject to delay and damage by aerial bombardment of all the transportation agencies now in use, must be given every possible opportunity to give the maximum service of which it is capable.

Closer cooperation needed

"It appears that closer cooperation could be effected, as between the military and the road-building and management agencies. This is particularly true with reference to the movement of convoys on the strategic system, and with reference to the improvements that are now very necessary in order that both new and expanding manufacturing plants engaged in the building of important defense products may be properly served.

"In summing up the general situation with reference to the transportation problem in Britain, it is desired to point out that after almost two years of war the British Government has now found it very necessary to coordinate and control all forms of transportation. A new agency has just been established that will, in effect, have absolute control over railroads, highways, canals, and shipping. It is understood that this most important agency will establish priorities and will determine by what type of transportation all important commodities and materials shall be moved. It will probably also control rates that can be charged for these movements."

More Durable Concrete with Treated Cement

M. A. Swayze

Director of Research, Lone Star Cement Corp.
Hudson, N. Y.

***Contents in Brief**—Additions to cement of such organic materials as mineral oils, animal or vegetable fats or natural resins result in concrete of greater impermeability, improved workability and reduced bleeding. Some reduction in strength occurs, but resistance to freezing and thawing is substantially increased. Tests and field service indicate Vinsol resin gives best results. Optimum quantity to be added is from 0.02 to 0.03 percent.*

FOR THE PAST SEVEN YEARS the Lone Star Research Laboratory has noted material increases in resistance to frost action for concrete when certain organic materials have been added to the cement in small quantities. These materials belong chemically to at least three classes, but have the common properties of being insoluble in the mixing water, of producing minute air cells in the mixed concrete, and usually of increasing concrete workability.

The three classes of materials studied were: (1) mineral oils; (2) animal or vegetable fats or oils; and (3) natural resins.

The effects of these substances on concrete strength, volume change, percent of air voids and durability are shown in the accompanying tables.

Mineral oils

A mineral oil admixture may be termed an inadvertent addition, entering the cement through leakage of bearings in some types of grinding machinery. In former years, complete grinding of cement in these mills introduced as much as 0.05 to 0.10 percent of oil into cement. Recently, better design of mill bearings and adoption of other types of grinding machinery by the industry have materially decreased or entirely stopped this leakage.

Table 1 affords a typical comparison of concrete quality obtained with a Type 2 cement and with one of identical composition and fineness, ground with 0.03 per cent crusher oil. The regular physical tests of the two products were practically the same.

It will be seen that the oil addition has little effect on either workability or strength. Air voids are only slightly increased, as shown by the concrete unit weight. Durability in freezing and thawing was increased in both mixes by the oil addition.

Animal or vegetable fats

Additions of animal or vegetable fats or oils have been made to portland cement for many years for purposes of obtaining "waterproof" products, or for increasing resistance to warehouse set when long periods of such storage are contemplated. Several series of tests have been run on pairs of commercial cements, one of each containing 0.03 percent beef tallow. Table 2 gives a typical comparison of the effect on concrete properties. The cements were of Lehigh Valley origin, and were of Type 1 composition.

Concrete batches were made containing from 3.5 to 7.0 sacks of cement per cubic yard. In each the weighed proportion of cement to aggregate was kept constant. Sand content of each mix was at the optimum for best workability. Water additions were varied to produce slumps of 2 and 6 in. All data are averages of three tests.

The increase in air content induced by the tallow increased yield and caused a reduction in quantity of cement per cubic yard. Therefore, greater reductions in strengths of the tallow concrete were obtained than would have resulted if the comparison had been on the basis of equal cement contents.

Regarding strength, it is noteworthy that in the lean mix range little loss in strength can be charged to the presence of the admixture. This is important, since so many concretes designed purely to meet a definite strength requirement fall into this class of mixes, and contain too little cement for good workability, density or resistance to frost action. Richer mixes generally have far more strength than is used in concrete design, and the greater decrease in strength by the admixtures in this range, therefore, seems relatively unimportant.

The effect of tallow on the air content of concrete is variable. Increase in voids is greater as cement content is lowered; voids also increase with higher slumps.

Shrinkage of concrete in air is increased by tallow additions. In the tests reported in Table 2, which were made at 50-percent relative humidity, the average increase amounts to 13 per cent. Similar increases in the shrinkage of concrete have been found in other tests.

The greatest effect of tallow or resin additions to cement is on resistance to freezing and thawing. While the durability of all mixes is increased, the effect is greatest in the lean mix range and least for the 7.5

TABLE 1—EFFECT OF 0.03-PERCENT CRUSHER OIL IN CEMENT ON CONCRETE PROPERTIES

	6.0 Sacks/Cu.Yd.; 5.4 Gal. Water/Sack.		4.5 Sacks/Cu.Yd.; 7.5 Gal. Water/Sack.	
	Normal Cement	Treated Cement	Normal Cement	Treated Cement
Slump, in.	2.3	2.3	3.2	4.0
Flow, percent	149	152	171	180
Wt/Cu.Ft.	151.2	150.5	149.6	149.0
Comp. Str. 1 da.	1410	1450	710	650
" " 3 "	3270	3420	1990	2190
" " 7 "	4020	4380	2730	2920
" " 28 "	5780	5770	3980	4020
" " 3 mo.	6580	6880	4650	4620
" " 1 yr.	7270	7400	4870	4970
Freezing Cycles*.	76	106	56	74
Relative Durability	100%	140%	100%	137%

* Freezing cycles on 3 x 6 x 6-in. specimens. Tests started at 28 day age, and continued until 20 percent loss of weight was sustained. Temperature range of cycle −20 deg. to +70 deg. F.

TABLE 2—COMPARISON OF CONCRETES MADE WITH NORMAL AND TALLOW CEMENTS

Compressive Strength—lb. per sq. in.

Sacks Cu.yd.	Net W/C	Flow %	Slump In.	Wgt. Cu.yd.	Voids %	Strength, 1 Da	3 Da	7 Da	28 Da	3 Mo	1 Yr
2" Slump Concrete, Moist Curing Cement "E"—No Admixture											
3.46	9.75	164	1.7	145.3	3.1	270	830	1470	2120	2390	2280
4.24	7.57	163	2.0	146.7	3.7	460	1470	2320	3470	3620	3900
5.02	6.05	157	2.0	148.8	3.1	730	2350	3480	4800	4980	5270
6.01	5.05	156	2.1	150.8	2.3	1110	3300	4530	5780	6120	6240
7.54	4.22	154	2.4	151.7	1.8	1640	3960	5380	6260	6990	7520
Cement "E_1"—0.030% Beef Tallow											
3.32	8.18	159	1.9	137.8	10.1	260	930	1530	2040	2440	2280
4.10	6.41	153	2.0	140.4	9.2	420	1490	2500	3210	3670	3460
4.81	5.64	160	2.2	141.9	8.3	560	1900	2860	3970	4200	4250
5.76	4.96	157	2.3	144.2	6.6	740	2530	3710	4720	4900	5330
7.11	4.36	161	2.2	146.0	5.1	960	2880	4280	4600	5440	5740
6" Slump Concrete—Moist Curing Cement "E"—No Admixture											
3.42	10.66	194	5.3	144.3	3.4	220	810	1190	1900	2140	2070
4.21	8.25	203	6.2	146.4	2.9	350	1240	1940	3160	3050	2760
4.94	6.82	205	6.3	147.8	2.8	540	1940	2960	3940	4370	4600
5.94	5.40	184	6.0	149.7	2.3	940	2950	4040	5610	5550	6600
7.40	4.61	183	6.2	149.9	2.0	1250	3480	4750	6270	6240	7330
Cement "E_1"—0.030% Beef Tallow											
3.23	8.62	177	5.9	134.5	11.9	200	750	1180	1910	2040	1800
3.90	7.00	192	6.2	135.7	11.5	310	1120	1760	2630	2690	2660
4.65	5.95	191	6.0	137.6	10.6	390	1450	2200	3110	3220	3280
5.54	5.18	189	6.0	139.1	9.5	500	1760	2650	3510	3650	3850
6.95	4.69	193	6.0	140.7	8.0	640	2150	3040	3940	4380	4630

Volume Change—Shrinkage In Air, Percent

2" Slump Concrete: Sacks Per Cu.yd.	3 Da	7 Da	28 Da	3 Mo	1 Yr	6" Slump Concrete: Sacks Per Cu.yd.	3 Da	7 Da	28 Da	3 Mo	1 Yr
Cement "E"—No Admixture											
3.46	.013	.021	.044	.064	.066	3.42	.020	.028	.045	.047	.045
4.24	.016	.023	.044	.051	.053	4.21	.009	.017	.044	.046	.051
5.02	.009	.017	.036	.045	.045	4.94	.011	.017	.038	.045	.046
6.01	.011	.017	.038	.048	.050	5.94	.014	.019	.040	.048	.051
7.54	.013	.020	.040	.054	.055	7.40	.010	.015	.038	.047	.049
Cement "E_1"—0.030% Beef Tallow											
3.32	.031	.056	.075	.087	.087	3.23	.007	.033	.055	.062	.062
4.10	.025	.033	.059	.068	.067	3.90	.019	.025	.052	.058	.058
4.81	.021	.033	.057	.069	.066	4.65	.017	.025	.050	.068	.060
5.76	.020	.031	.056	.070	.071	5.54	.021	.031	.062	.071	.071
7.11	.016	.024	.050	.065	.063	6.95	.016	.026	.057	.066	.073

Resistance to Freezing and Thawing

2" Slump Concrete		6" Slump Concrete	
Cement "E"—No Admixture			
3.46	20.0% Loss @ 56 Cycles	3.42	20.0% Loss @ 59 Cycles
4.24	20.0% Loss @ 98 Cycles	4.21	20.0% Loss @ 83 Cycles
5.02	20.0% Loss @ 134 Cycles	4.94	20.0% Loss @ 104 Cycles
6.01	1.1% Loss @ 150 Cycles	5.94	6.9% Loss @ 150 Cycles
7.54	1.2% Loss @ 150 Cycles	7.40	1.1% Loss @ 150 Cycles
Cement "E_1"—0.030% Beef Tallow			
3.32	9.2% Loss @ 150 Cycles	3.23	5.6% Loss @ 150 Cycles
4.10	5.9% Loss @ 150 Cycles	3.90	5.0% Loss @ 150 Cycles
4.81	0.8% Loss @ 150 Cycles	4.65	0.7% Loss @ 150 Cycles
5.76	1.4% Loss @ 150 Cycles	5.54	0.4% Loss @ 150 Cycles
7.11	1.1% Loss @ 150 Cycles	6.95	0.4% Loss @ 150 Cycles

sack batches, which by their low water content are normally of high resistance even with untreated cements.

A very significant difference is notable in the type of disintegration obtained. Normally, frost attack is always at the top surface of concrete, showing up as a scaling of the finished surface. As the number of freezing cycles mount, this scaling progresses downward, with real disintegration generally confined to the top half of the test specimen. Both resin and tallow additions to cement prevent this differential action. Scaling or disintegration of concrete containing these materials takes place much more slowly, and the frost attack is quite uniformly distributed over all surfaces of test specimens. This difference is of great importance in actual weathering of exposed concrete. Many highway engineers have stated that more durable concrete roads would be obtained if the slabs after curing could be turned over. It now appears possible to attain the same result with treated cements.

Natural resins

Such materials as gum or wood resin, have been used occasionally to clean grinding media in finish tube mills, but in such small quantities that the effect on concrete has been negligible. When added continuously in an amount from 0.01 to 0.05 percent, however, the effects are striking as shown in Table 3. The Vinsol resin utilized is a product extracted from pine wood by a special process, but similar results have been obtained with ordinary resin. The increments of resin addition were obtained by blending a Type 1 cement with an otherwise identical sample containing 0.05 percent resin.

The basic concrete batch was designed according to an Eastern state highway specification. Weighed proportions of cement and aggregate were constant, with water variable to produce the desired slump. This procedure gave a reduction in cement content of 1½–4 percent, depending on the quantity of resin present.

Strength reductions due to increased air content ranged from 5 to 20 per cent, and were less than those found for similar tallow additions, not reported here. Volume change of concrete was not affected by any of the quantities of resin represented.

Resistance to freezing and thawing was markedly increased by the first 0.01-percent increment of resin addition. Further increases in durability resulted with additional increments, but the change was not so great.

A further effect of resin or tallow additions that cannot be expressed in test data is their effect on workability of concrete. Since slump and flow figures in the data are nearly identical, it might be concluded erroneously that workability also was constant. Actually, a decided increase in plastic properties is noted even with as little as 0.01 percent of these materials present. Mixes are easier to deform under pressure, placing is easier, and the cement paste holds more firmly to the aggregates, with little or no segregation of water on standing. All these effects are obtained by the first 0.01 percent of addition; further increases had a smaller increment of effectiveness.

TABLE 3—EFFECT OF VINSOL RESIN ON HIGHWAY CONCRETE

Compressive Strength—lb. per sq. in.

Resin %	Water Gal/ Sack	Sacks Per Cu.yd.	Wt. Per Cu.ft.	% Air Voids	Slump In.	Flow %	Strengths 1 Da	3 Da	7 Da	28 Da	3 Mo	1 Yr
None	5.41	6.12	149.0	2.4	2.5	169	1100	2860	4090	5540	6220	6600
.01	5.29	6.04	146.6	4.2	2.5	164	1000	2730	3870	5230	5780	6200
.02	5.12	5.99	145.2	5.1	2.5	163	950	2700	3750	4990	5640	6170
.03	5.11	5.85	141.8	7.7	3.2	175	930	2380	3740	4430	5090	5160
.04	5.01	5.89	142.3	7.5	2.5	165	760	2500	3720	4670	5290	5340
.05	4.95	5.88	142.0	7.9	2.5	165	670	2430	3750	4780	5270	5440

Concrete Volume Change—3"x3"x12" Beams

Resin %	Expansion in Water, Percent 3 Da	7 Da	28 Da	3 Mo	1 Yr	Shrinkage in Air, Percent 3 Da	7 Da	28 Da	3 Mo	1 Yr
None	.000	.001	.004	.005	.011	.010	.018	.038	.058	.057
.01	.001	.000	.004	.004	.010	.010	.018	.040	.057	.058
.02	.001	000	.004	.003	.008	.009	.016	.041	.057	.055
.03	.000	.001	.005	.004	.009	.009	.016	.041	.056	.054
.04	.002	.002	.003	.005	.011	.009	.014	.041	.060	.058
.05	.000	.002	.006	.004	.011	.009	.018	.045	.058	.056

Resistance to Freezing and Thawing*

% Resin	In 10% Calcium Chloride	In Plain Water
None	20.0% Loss @ 115 Cycles	12.0% Loss @ 150 Cycles
.01	6.5% Loss @ 150 Cycles	2.3% Loss @ 150 Cycles
.02	4.2% Loss @ 150 Cycles	3.3% Loss @ 150 Cycles
.03	4.5% Loss @ 150 Cycles	1.1% Loss @ 150 Cycles
.04	4.1% Loss @ 150 Cycles	0.6% Loss @ 150 Cycles
.05	3.8% Loss @ 150 Cycles	0.6% Loss @ 150 Cycles

*Three cycles —20 deg. to +70 deg. F. per day, beginning at 28-day age.

Table 4 shows a comparison of a Type 1 normal portland with one of identical composition, but containing 0.02 percent Vinsol resin. The treated cement was considerably coarser than the normal product. Concrete batches were the same as those in Table 2.

The effect of the resin on the air content of the concrete, as in the case of tallow treatment, again is variable, lean or wet mixes being affected more than richer or stiffer batches. Concrete shrinkage in air at 50-percent relative humidity is not appreciably affected by the admixture.

Durability is greatly promoted by the small quantity of resin, especially in the leaner types of concrete, where this quality is so generally of a low order.

The most striking effect of this resin addition, outside its contribution to durability, lies in its influence on concrete strength. While 1-yr. values of 5-bag or richer mixes are lower than with normal cement, the strength of the leaner batches is actually higher for the treated product.

Concrete permeability

While regular permeability tests were not made, two types of observations have repeatedly indicated that concrete containing these treated cements is more resistant to passage of water than ordinary concrete. First, when 6x12-in. cylinders have been stored in fog for 28 days or longer, their interiors always appear damp on breaking. With cements containing resin or tallow, this internal moisture is much less in evidence. A considerable number of cylinders whose surfaces had been continuously wet for 5 years were recently broken and revealed practically dry interiors.

The second type of observation has been on thin sections of concrete. In this work it is necessary to expel all uncombined water, and then fill the resulting air spaces with a mounting resin in order to obtain clear sections for microscopic study. With normal concrete this is readily accomplished. With treated cements, however, it is often impossible to saturate the specimens with mounting resin on account of their low rate of absorption.

These observations lead to the belief that the high resistance of concrete to freezing and thawing, when the admixtures under consideration are present, is due to the influence of the resin or fat on the microstructure of the hardened paste. The capillaries in these pastes must be of considerably smaller size when these admixtures are present.

The import of these deductions to the field of highway concrete is that, with adequate curing, the highway slabs, after once becoming dry by combination or evaporation of the mixing water, never become resaturated when admixtures such as the resins or fats are present. Since alternations of temperature above and below freezing have no significance to dry concrete (except for the stresses due to thermal volume change), the effect of frost action on these special concretes is materially less than is encountered in normal mixes.

Conclusions

Data from many more tests than are presented here have shown that durability of portland cement concrete may be improved materially by the introduction of small quantities of water-repellent materials into the cement. Workability and plasticity of fresh concrete is also improved by the additions. Bleeding, especially in the lean mix range, is reduced to a minimum by the resins or fats, but is not appreciably changed by mineral oils.

The quantity of material which may be added to portland cement without more than moderate reductions in compressive strength or increases in air content of concrete is dependent on the character of the added material, the type of concrete mix, and to some extent the composition or other properties of the cement to be treated. From data obtained in the Lone Star Research Laboratory, the optimum quantities are about as follows:

Mineral oils	0.04 to .06 percent
Animal fats or oils	0.01 to .03 percent
Vinsol resin	0.02 to .03 percent

In the design of concrete batches for field use, an increase in quantity of treated cement of 4 to 6 percent by weight is required to maintain a cement factor equivalent to that with normal portlands. Decreases in concrete strength which have been obtained with the admixtures would be less if constant cement contents had been maintained.

The percentage of air content in concrete induced by resins or fats is dependent on water-cement ratio, and also on the consistency in terms of slump. Air content increases are least in rich mixes of stiff consistency, and greatest in lean and wet mixes.

The greater amount of air cells in treated cement concrete is not believed to be the source of higher durability, but merely an incidental characteristic. The basic reason for greater durability apparently is the

TABLE 4—COMPARISON OF CONCRETES MADE WITH NORMAL AND RESIN CEMENTS

Compressive Strength—lb. per sq. in.

Sacks Cu.yd.	Net W/C	Flow %	Slump In.	Wgt Cu.ft.	Voids %	Strengths 1 Da	3 Da	7 Da	28 Da	3 Mo	1 Yr
2" Slump Concrete — Moist Curing											
Cement "H"— No Admixture — 2040 Specific Surface											
3.49	9.54	159	1.9	146.4	3.1	250	1140	1820	2460	2340	2230
4.27	7.80	171	2.1	147.9	2.6	400	1820	2720	3670	3570	3540
5.05	6.21	158	2.0	149.9	2.3	730	2670	3990	4750	4940	5380
6.00	5.11	160	2.0	150.6	2.1	1180	3390	5110	5480	6120	6490
7.51	4.36	157	2.1	151.5	1.6	1870	4110	5600	6280	6950	7620
Cement "H_1"— 0.020% Vinsol Resin — 1670 Specific Surface											
3.42	8.60	151	1.9	142.4	6.8	270	890	1610	2290	2410	2560
4.22	6.90	154	2.0	145.2	5.7	420	1300	2280	3140	3420	3670
4.95	5.94	163	2.2	146.5	4.8	570	1840	2940	3960	4450	4710
5.95	5.04	159	2.0	148.8	3.5	850	2480	4000	4710	5480	6030
7.52	4.19	154	2.0	151.1	2.2	1410	3490	4600	5560	5860	6580
6" Slump Concrete — Moist Curing											
Cement "H"— No Admixture — 2040 Specific Surface											
3.46	10.69	210	5.9	146.2	2.1	170	830	1440	1830	1930	1870
4.24	8.22	200	6.0	147.6	2.2	350	1500	2370	3390	3410	3430
4.99	6.77	192	6.0	149.1	1.9	580	2200	3320	4140	4550	4720
5.95	5.64	192	6.0	150.2	1.5	930	3050	4490	4880	5580	5990
7.41	4.80	198	6.0	150.6	1.2	1580	3490	5040	5650	6170	6930
Cement "H_1"— 0.020% Vinsol Resin — 1670 Specific Surface											
3.31	9.38	198	6.2	138.6	8.8	240	740	1250	1920	2040	2130
4.11	7.23	191	6.0	141.9	7.1	370	1250	2080	3000	3180	3500
4.82	6.17	197	6.0	143.3	6.2	500	1700	2590	3700	4190	4340
5.80	5.35	181	6.0	146.0	4.8	740	2300	3470	4760	5230	5470
7.27	4.64	189	6.0	147.1	3.7	1070	2700	4140	5060	5860	6340

Volume Changes—Shrinkage In Air, Percent

2" Slump Concrete: Sacks Per Cu.yd.	3 Da	7 Da	28 Da	3 Mo	1 Yr	6" Slump Concrete: Sacks Per Cu.yd.	3 Da	7 Da	28 Da	3 Mo	1 Yr
Cement "H"— No Admixture											
3.49	.028	.036	.059	.066	.067	3.46	.010	.016	.034	.042	.048
4.27	.013	.021	.041	.053	.054	4.24	.016	.024	.045	.055	.060
5.05	.015	.024	.044	.057	.059	4.99	.016	.022	.044	.056	.061
6.00	.017	.023	.041	.056	.060	5.95	.014	.021	.038	.053	.058
7.51	.016	.025	.040	.054	.057	7.41	.016	.023	.047	.059	.067
Cement "H_1"— 0.020% Vinsol Resin											
3.42	.019	.026	.043	.047	.052	3.31	.024	.033	.056	.060	.063
4.22	.021	.034	.051	.056	.056	4.11	.017	.021	.046	.052	.055
4.95	.017	.025	.044	.052	.054	4.82	.020	.025	.045	.055	.059
5.95	.021	.043	.053	.062	.068	5.80	.017	.022	.047	.057	.061
7.52	.019	.025	.043	.054	.060	7.27	.017	.018	.043	.053	.059

Resistance to Freezing and Thawing

Sacks Per Cu.yd.	2" Slump Concrete	6" Slump Concrete
Cement "H"— No Admixture		
3.49	20.0% Loss @ 48 Cycles	3.46 — 20.0% Loss @ 57 Cycles
4.27	20.0% Loss @ 66 Cycles	4.24 — 20.0% Loss @ 76 Cycles
5.05	20.0% Loss @ 137 Cycles	4.99 — 20.0% Loss @ 99 Cycles
6.00	1.1% Loss @ 150 Cycles	5.95 — 20.0% Loss @ 145 Cycles
7.51	0.0% Loss @ 150 Cycles	7.41 — 2.0% Loss @ 150 Cycles
Cement "H_1"— 0.020% Vinsol Resin		
3.42	11.3% Loss @ 150 Cycles	3.31 — 7.3% Loss @ 150 Cycles
4.22	6.1% Loss @ 150 Cycles	4.11 — 7.2% Loss @ 150 Cycles
4.95	1.5% Loss @ 150 Cycles	4.82 — 1.9% Loss @ 150 Cycles
5.95	1.1% Loss @ 150 Cycles	5.80 — 1.7% Loss @ 150 Cycles
7.52	0.4% Loss @ 150 Cycles	7.27 — 0.9% Loss @ 150 Cycles

effect of the admixtures on permeability of concrete.

Shrinkage of concrete on drying has not been appreciably affected by additions of resins or mineral oil in any of many tests. Animal fats have materially increased shrinkage in all but one series of results. None of the admixtures tested had any influence on volume change in water storage.

Since drying shrinkage is a serious factor in most concrete construction, the use of resins or mineral oil is much preferable to the animal fats. As the resins have greater effect than mineral oils in promoting concrete durability, they offer the greatest potentialities for improvement in concrete characteristics.

Field use of these special cements in highway and structures has checked these laboratory findings. The construction of a 300,000-bbl. silo warehouse and packhouse at the company's Hudson plant last year served as a proving ground for the Vinsol resin addition. The same increases in concrete workability and freedom from segregation were found as in laboratory studies. The high impermeability of this type of concrete has been indicated by the notably dryer condition of the finished silo interiors. No frost action can be found, even on Class B concrete, although conditions for such action have been severe.

City Housekeeping Costs Go Up in a Boom Town

It's good business for merchants to have an army camp near the city, but it takes a lot out of the city treasury just to meet street cleaning and refuse collection costs. So conclude officials of Columbus, Ga., army boom town near Fort Benning, where a monthly camp payroll of $4,500,000 is distributed. On army pay-days the rush of retail trade is so great, reports the American Public Works Association, that the littered streets take on the look of circus day, and the sanitation department is called on for double duty.

Refuse collections for the first quarter of 1941 show an increase of 40 percent over the same period in 1940, before thousands of soldiers and construction workers were added to the local population. The increase of traffic has added to collection difficulties because pickups from alleys can be made in less than 40 percent of the business section. To meet this problem, additional equipment and more street cleaners have been provided, collection schedules rearranged, and householders asked to separate refuse for collection.

Other public works problems have shown up in Columbus. The amount of maintenance required on both paved and unpaved streets has grown because of increased traffic and the number of service cuts necessary for providing gas, water and sewers to new building construction. More than 90 percent of the laborers on city WPA sewer and paving projects have gone over to private and "defense" construction work, and 30 streets that the city had decided should be improved must now go unpaved because of lack of labor.

The need of parking accommodations has grown so acute that rigid restrictions have been placed on parking in the business area, with metered parking only permitted on the most congested streets.

BUILDING DESIGNERS' LIBRARY

Cantilever and Combined Footing Designs Compared

H. S. Woodward
Structural Engineer, Larchmont, N. Y.

***Contents in Brief**—Combined footings found to be more expensive by an amount varying from 20 to 70 percent on spans from 19 to 38 ft. Decreasing distance between columns makes combined footings more logical choice. Strap for cantilever footing should not have a bearing on the soil. Long cantilever arms may produce opposite action at interior end, due to the weight of the strap, developing point of inflection.*

THERE ARE NUMEROUS OCCASIONS in the design of foundations where the choice has to be made between a combined or a cantilever footing. It then becomes principally a question of economics. The writer has had numerous cases of this kind and as a matter of curiosity has designed both types completely and compared the costs. Most of the comparisons were made for soil values of 2 to 3 tons per sq. ft. but the variation for other values is about the same.

It was thought that there might be some definite relation between the two footings, varying with the span between columns. After numerous comparisons were made on the basis of cost there appeared to be no such relation even though the proportions of the cantilever footings were kept the same. No two designers would arrive at the same cost for a complicated footing of these types because of the different proportions which may be assumed, details of design (such as cutting off bars for moment), shear considerations, and other factors involved. A 10-percent variation in two designs for the same footing would not be at all surprising. With the combined footing not so much variation is possible due to the fact that the center of gravity of loads and footing are fixed. The only variations would be in depth and consequent reinforcing difference.

In the comparisons made it was found that the combined footing was more expensive than the cantilever by an amount which could vary considerably according to design but ranged from 20 to 70 percent more. The distance center to center of columns in the cases used varied from 19 to 38½ ft.

As the distance between columns becomes less, the choice of the combined footing becomes more logical regardless of cost. One reason for this is the chance of unequal settlement of two closely spaced columns. Also the action of a relatively large cantilever footing with a short arm is questionable, in fact it may be questionable in any case.

An elementary requisite in cantilever footing design is that the strap should not bear on the soil, as this condition would upset the theory of design. It is because of this that a cantilever footing is not as foolproof in construction as the combined. To obviate such action the writer never designs the strap the same depth as the main footing. The strap is specified to be formed on the bottom and the forms removed. At least a 4-in. difference in depth is desirable. The backfilling under the strap will then not be sufficiently compacted to furnish any support that would affect the design assumption.

In proportioning a cantilever footing considerable time is often consumed in reaching the right proportions in order that the bearing area takes care not only of the column load but the strap weight, as well as the additional load due to cantilever action. It has been the writer's experience that the proportions shown in Fig. 1 work out well. If it is assumed

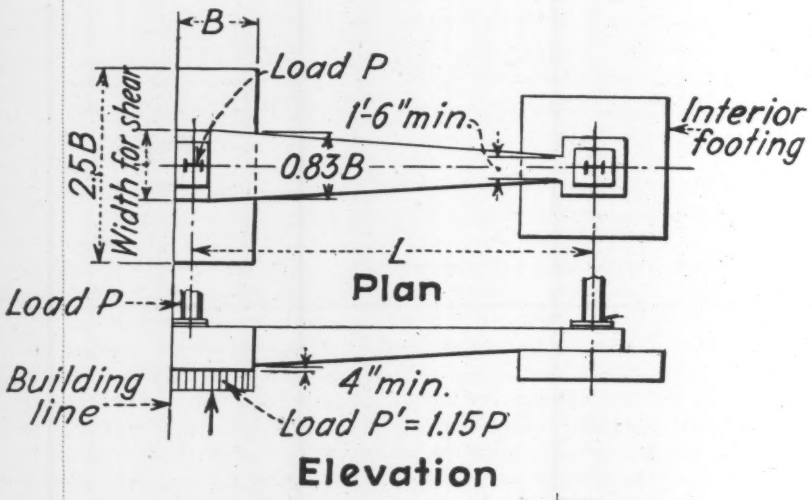


Fig. 1. Well-proportioned design for cantilever footing showing relative dimensions and strap arrangement.

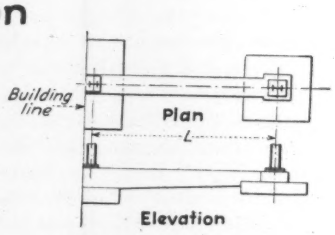


Fig. 2. To save excavation or clear another footing the strap may be kept high.

that the load P' is about 1.15 P the strap weight and cantilever action will usually be covered. This is true for soil values of 2 or 3 tons. For higher soil values 1.10 P will be adequate. Assuming a low soil value then:

$$P' = S \times B \times 2.5\,B$$

where S is the soil value minus footing weight (assumed from experience at 300 to 400 lb. per sq.ft. Substituting P for P' and solving for B we have

$$B = \sqrt{\frac{1.15\,P}{2.5\,S}}$$

This immediately gives the main footing size and the other approximate strap dimensions. The final results are then obtained and checked with the assumptions.

Another point might be noted in connection with the design. If the strap has a tapered shape as shown in Fig. 1 the width used for shear at the column may be that indicated. This may be of considerable advantage in stirrup elimination in some cases.

One point in this connection has always been questioned in the writer's mind. The shear on the strap at the exterior column is always figured with a width equal to that of the strap at that point. With the strap and footing having a flush top this width appears to be too conservative. There is evidently no reason why more width should not be used for diagonal tension, how much could be decided by tests. Considerable savings in stirrups would result with a slight concession of this kind. This condition is comparable to that of a beam which is flared at its support to provide more width for shear. In the case the full width is figured for diagonal tension. Of course a definite limit should be fixed.

Several variations in the type of cantilever footings are possible. There are numerous occasions where it is necessary to go to a certain depth for good soil. In this case the strap is kept high to save excavation, resulting in the design shown in Fig. 2. In a design of this kind the footing of the cantilever may be dropped to any depth by having the strap frame into a pier which rests on the footing. In some cases the writer has found it necessary to clear an adjoining footing. This was accomplished by moving the footing away from the building line and letting the strap cantilever pick up the exterior column.

In cases of long cantilever arms instead of an uplift at the interior end the opposite action results due to the weight of the strap. This, of course, gives a point of inflection in the strap with bottom steel necessary. The same result usually occurs if another load rides on the strap, such as a strut load for example. Some engineers try to avoid a condition of this kind, due, it is presumed, to the uncertain action of the strap. Where the riding load is relatively light, the design should prove satisfactory.

Cost of the St. Lawrence Project

MINOR DISCREPANCIES were present in the tables of estimates of the cost of the St. Lawrence power and navigation project published in the May 22 issue (p. 831) due to an apparent conflict between estimates of government agencies concerned with the project. Those discrepancies now have been cleared up. Revised tables VI and VII are given herewith. No major changes have been made from the figures given in the May 22 issue, but by including the cost of constructing remedial works above Niagara Falls in Table VI, which was not done originally, and making minor adjustments in figures for expenditures made to date, the estimates of the total work yet to be done as given in Table VI agree with the totals for the allocation of those costs as given in Table VII.

In Fig. 7 of the same article the units used in the diagram of peak loads on the Niagara-Hudson system should be kilowatts instead of horsepower as shown in column at right.

TABLE VI—ESTIMATED COST OF GREAT LAKES-ST. LAWRENCE SEAWAY—1941

(Navigable channel 27 ft. deep)

	Canada	United States	Totals
Great Lakes Section:			
New lock at Sault Ste. Marie	.....	$8,000,000	$8,000,000
Connecting Channels	.....	66,029,500	66,029,500
Welland Canal	$133,000,000	.....	133,000,000
Niagara River:			
Remedial works above the falls	838,450	838,450	1,676,900
St. Lawrence River:			
Thousand Island Section	772,000	516,000	1,288,000
International Rapids Section;			
A. Works solely for navigation	.....	38,578,000	38,578,000
B. Works primarily for power	25,164,000	71,640,000	96,804,000
C. Works common to navigation and power	22,414,000	108,374,000	130,788,000
Lake St. Francis Section	1,330,000	.....	1,330,000
Soulanges Section	25,785,000	.....	25,785,000
Lachine Section	55,839,000	.....	55,839,000
Totals	$265,142,450	$293,975,950	$559,118,400
Expenditures to date	$132,672,000	$17,105,500	$149,777,500
Cost to complete	$132,470,450	$276,870,450	$409,340,900

TABLE VII—COST ALLOCATIONS UNDER 1941 AGREEMENT*

	United States	Canada	Total
Lachine — Soulanges	.....	$82,954,000[1]	$82,954,000
International Rapids	$218,592,000[2]	47,578,000[2]	266,170,000
Welland Canal	.....	1,100,000[1]	1,100,000
Niagara remedial works	838,450[3]	838,450[3]	1,676,900
Great Lakes Channels	49,440,000[4]	.....	49,440,000
New lock, Sault Ste. Marie	8,000,000[4]	.....	8,000,000
Totals	$276,870,450	$132,470,450	$409,340,900

* This table is not official. It was prepared by *Engineering News-Record* from the best available cost estimates, as indicated in the footnotes.

[1] Report to the Canadian House of Commons, March 21, 1941.
[2] Cost estimates of the Engineering Board of 1941.
[3] Canada-Ontario Agreement of 1941.
[4] Estimates of the Chief of Engineers, U. S. Army.

Book Notes and Reviews

The month's addition to the engineer's reading and reference list

Drawing for Engineers

ENGINEERING DRAWING—6th Edition. By Thomas E. French. 622 pp. Published by McGraw-Hill Book Co., New York and London. Price $3.

STRUCTURAL DRAFTING—By Carlton T. Bishop. 287 pp. Published by John Wiley & Sons, New York; Chapman & Hall, London. Price $3.50.

Prof. French's well-known text has been expanded and reset on a larger page to give better presentation of the illustrations. All illustrations of material covered by standards of the American Standards Association now conform to those standards. Indicating the trend of the times is a new chapter on aircraft drawing.

The new text by Prof. Bishop relates chiefly to the work of structural-steel draftsmen. Drafting requirements for concrete and timber structures are only briefly discussed. The book has been developed as a companion for Structural Design (1938) by the same author and contains much of the material that appeared originally in Structural Drafting and Design. This material has been rewritten.

Soil Mechanics

SOIL MECHANICS—By Dimitri Krynine. 451 pp. Published by McGraw-Hill Book Co., New York and London. Price $5.

This important new text on soil mechanics presents in clear and understandable form the fundamental principles and concepts of that science. Part I is devoted to a consideration of the physical character of soil, particularly the important effect of moisture on soil. Seepage phenomena and frost action are treated in considerable detail. Part II treats of the behavior of soil under the action of applied loads. Determination of the stress conditions imposed on the soil by these applied loads is discussed, including methods, applications, and limitations of the theory of elasticity. Following this, the fundamental principles and concepts involved in the stress-strain relationships are considered. These define the behavior or reaction of the soil under stress. The consolidation of soils and shearing failure in soils are considered in some detail.

Part III is devoted to the applications of soil mechanics to practical foundation problems, such as the factors involved in the analysis and design of spread foundations and pile foundations. The conditions for stability and failure and the methods of analysis of embankments, retaining walls, and bulkheads also are covered. The chapter on settlement of structures represents a most important part of the book, covering causes of settlement, damage resulting from settlement, methods of estimating the amount and rate of settlement, methods of reducing settlement. Numerous cases are given as illustrations, which represent a very valuable fund of knowledge on the behavior of structures.

This text should prove of great value not only to the student but also to the engineer who wishes to acquaint himself with the fundamental principles and concepts of soil mechanics and their practical applications to foundation engineering.—*Reviewed by* DONALD M. BURMISTER, *assistant professor of civil engineering, Columbia University, New York.*

Miscellaneous Notes on Booklets and Reprints

OUR HIGHWAYS—A NATIONAL ASSET is the title of a pamphlet put out by the highway economics division of the American Road Builders Association, Transportation Building, Washington, D. C. It sets forth some of the economic considerations relating to highways, and provides material to be used by those arguing in support of expansion of our national highway system.

A DIGEST OF LICENSE LAWS for engineers on the statute books of all states having such laws has been prepared by the National Council of State Boards of Engineering Examiners. It covers only matters of interest to engineers in the practice of their profession and does not include administrative sections of the laws. Copies may be obtained from T. Keith Legaré, executive secretary of the council, Box 1404, Columbia, S. C. Price $2.

MODERNIZATION of an ice-control system for a state highway department, a paper that appeared originally in *Roads and Streets*, has been reprinted by the Calcium Chloride Association, Penobscot Building, Detroit, in the Calcium Chloride Association News of February, 1941.

New Engineering Books

AN ENGINEERS' MANUAL OF STATISTICAL METHODS—By Leslie E. Simon. 231 pp. Published by John Wiley & Sons, Inc., New York; Chapman & Hall, Ltd., London. Price $2.75. *Relates chiefly to the application of statistical methods to ordnance problems.*

LANDSCAPE ARCHITECTURE IN THE MODERN WORLD—By Karl B. Lohmann. 165 pp. and pictures. Published by the Garrard Press, Champaign, Ill. Price $2.50.

FINANCIAL STATISTICS OF STATES 1938—Vol. 3: Detailed Report. 168 pp. Prepared by U. S. Dept. of Commerce and Bureau of the Census. For sale by the Supt. of Documents, Washington, D. C. Price 25c.

POWER—By Franklin M. and Claire Reck. 154 pp. Published by Thomas Y. Crowell Co., 432 Fourth Ave., New York City. Price $2. *A popular approach.*

WATER TREATMENT—By G. V. James. 224 pp. Published in the United States by The Chemical Publishing Co., Inc., 234 King St., Brooklyn, N. Y. Price $12.

FOUNDATIONS OF BRIDGES AND BUILDINGS—By Henry S. Jacoby and Roland P. Davis. Third Edition. 535 pp. Published by McGraw-Hill Book Co., New York and London. Price $5.

WHO'S WHO IN ENGINEERING 1941—Fifth Edition. 2107 pp. Published by the Lewis Historical Publishing Co., New York City. Price $10.

MISSISSIPPI RIVER BRIDGE at New Orleans, La. Final Report. By Frank M. Masters, Modjeski & Masters, Harrisburg, Pa. Price $20 including supplemental drawings.

ENGINEERING DRAWING—6th Edition. By Thomas E. French. 622 pp. Published by McGraw-Hill Co., New York and London. Price $3.00.

STAHLBAU-KALENDER 1941—605 pp. Published by Wilhelm Ernst & Sohn, Berlin, Germany. Price 3.40 RM.

ENGINEERING NEWS-RECORD
Special Waterworks Section

IN THIS SECTION

Preparedness Headquarters — Harry Jordan . . . 82
Industry Is Mobilized — Karl M. Mann . . . 82
War and Water Service — Norman J. Howard . . . 83
Trouble Shooters at Work — J. S. Longwell . . . 84
Sentinels of Service — Paul Lippert . . . 87
Pooling Water Resources — Charles H. Capen . . . 89
Clean Mains and More Capacity — Clinton Inglee . . . 91
Main Sterilization — H. N. Armbrust . . . 93
Distribution System Diagnosis — Edgar K. Wilson . . . 95
Water for Fire Fighters . . . 97
From Field and Office . . . 99
New Equipment in Review . . . 106
Roster of Products . . . 127

Waterworks Preparedness

PREPAREDNESS is the word for waterworks today. With the nation geared for the greatest industrial production ever undertaken, a heavy obligation falls upon water utilities. Are they ready to meet all quantity and quality demands to service every need, normal as well as abnormal?

The answer to this question is not to be found in armchair analyses of miles of mains laid and millions of gallons stored, but must come from a realistic examination of the physical weaknesses and potentialities peculiar to each water system. This is a job that calls for rolled up shirt sleeves and quick action leading to the elimination of deficiencies.

For the waterworks man, preparedness means efficiency of plant operation and personnel. It is concerned with adequacy of supply, facilities for distribution equal to domestic, industrial and fire protection demands, and the availability of men and materials ready for use in emergencies. Waterworks preparedness is a triple-headed responsibility that mobilizes the resources of plant operator, engineer-specialist and equipment manufacturer.

Preparedness and how to achieve it is the theme of this special issue. Here the waterworks man will find practical articles on "tuning up" a system to highest efficiency. And here he will find a reference roster of equipment suppliers who stand ready to assist in the campaign of preparedness. In addition, there is a section on new developments which represent the latest contributions of industry to better service.

PREPAREDNESS HEADQUARTERS

WHAT IS THE PART that the American Water Works Association should take in preparedness measures? What can the association's staff and technical committees do to make its services useful to the people?

The American Water Works Association has made its members and its staff available for every kind of service that such men can give. Its engineers have planned and built many of the training camps for the Army. Some of them have acted as consultants to the General Staff. Some have joined with engineers from other fields in reviewing war experiences in Europe. They have helped to develop the manuals of information that are now being issued by government agencies on methods of protection if attack comes. While waterworks men have entered freely into military and naval training, their ability to be of special service is not being as fully used as had been hoped. But time and stress are good changers of habits, so it may be expected that the present waste of experience will not continue too long.

Waterworks managers are finding that the immense volume of defense production is restricting their ability to obtain equipment and supplies. Every manufacturer in the field is faced with the necessity of conserving his stock of basic metals. And the Office of Production Management on May 1 established control of inventories of many metals—some of which are used in waterworks equipment. As a result manufacturers must require that customers obtain preference ratings from the OPM before an order is accepted. The A.W.W.A. office has been in contact with the Priorities Division and is advised that materials required for public health and safety services (such as water supply) stand high in the rating list.

Now there has been set up a National Office of Civilian Defense to coordinate and guide state and city councils of defense that have been waiting for leadership. In these organizations waterworks men have been serving and will continue to serve. In this period of stress the American Water Works Association is prepared to render the same type of service that has done so much to promote the welfare of all in times of peace.

HARRY E. JORDAN
Secretary, American Water Works Association

INDUSTRY IS MOBILIZED

CONSENSUS of opinion in the water supply industry points to an active period of expansion. While the major deterrent to waterworks activity undoubtedly will be the problem of priorities, it is significant to note that within the so-called "Civilian List" of priorities, water supply requirements are in first place.

Meanwhile many manufacturers have accumulated reasonably adequate stocks of metals and other essential materials to prepare them for the great expansion that lies ahead, due to the following factors: increased water requirements in manufacturing plants working 24 hours a day in defense industries; requirements for industrial waste treatment in these plants; need for complete water systems in military, naval and aviation centers; increased needs in behalf of the civilian populations concentrating about these military establishments (estimated at 5 persons, including women and children, to every 10 men in camp); and finally, new construction of water supplies required by shifts of population into areas of new or expanded defense industries.

Beyond the factor of new construction, there exists a tremendous reservoir of activity in the preparation of existing water systems for withstanding abnormal conditions, whether of actual war, of sabotage or of fire hazard. There is rapidly growing recognition of need throughout the country's water systems for increased installation of valves and control devices as protection against service interruptions; need for additional mains for reserve supplies, duplicate pumping equipment, standby services, chlorinating units, storage tanks, hydrants, adequate reserve supplies of coupling units, emergency disinfecting chemicals and repair equipment of all kinds.

KARL M. MANN
President, Water and Sewage Works Manufacturers Association, Inc.

War and Water Service

Norman J. Howard
President, American Water Works Association, and
Director of Water Purification, Toronto, Ont., Can.

***Contents in Brief**—With the viewpoint obtained from personal visits to every part of this country and Canada, Mr. Howard outlines the broad responsibilities of the waterworks profession. This cogent recital of problems and their possible solution furnishes valuable information on which to base a course of action.*

ONE OF THE MOST VITAL ISSUES of today centers on waterworks preparedness. With both Canada and the United States geared for "all-out" industrial production, special dependence is placed on public utilities, particularly electric power and water supply. And the rapid construction of dwellings for defense workers throws an additional burden on water supply.

It seems probable that serious problems may arise because of abnormal conditions that hardly could have been foreseen. Demands for increased water daily become more manifest and instances are already evident where the question is serious. For example: In one municipality of 25,000 a military camp of 6,000 has been established; the city is now faced with providing facilities for a 20-percent increase in water consumption. And in several places where factories are being rushed to completion, production may be held up until adequate water facilities are provided. Throughout the country, notably in industrial areas, consumption of water has increased from 3 to 12 percent, and these figures promise to increase rapidly in the near future.

Quality important, too

Not only is the question of quantity involved but that of quality must receive grave consideration. In a recent report of the National Technological Committee (U. S.) which was issued following the return of United States engineers from the war zone, we are told that contamination of public water supplies by means of dried typhoid fever cultures must be regarded as a possibility. While there is no record of this having been attempted, the dropping of such matter in open reservoirs might be disastrous and would only be detected when a serious epidemic developed.

May I urge, therefore, the practice of continuous disinfection of all open reservoirs discharging water into the distribution system, particularly water which at present is not chlorinated immediately prior to entering the mains. Bacterial contamination may be possible, but no real danger from chemical poisoning is anticipated.

The question of water supply for military camps calls for careful consideration. At the present time in Canada about 110 camps have been established, and the subject of water supply definitely has not been given the consideration it merits. In not a few cases engineers untrained in purification problems have been called upon to solve difficult questions involved in chemical treatment. The safety of the supply has in some instances been left to the local health officers, and in most cases been relegated to chlorination alone. In the United States, while conditions regarding new camps are not yet ideal, a very careful study has been made of the problem and the country finecombed to secure experienced technical men to supervise the operation of water and sewage treatment plants. In this activity, the personnel of the American Water Works Association has been prominent.

There is no indication that Canadian waterworks, with the exception of Toronto, have prepared themselves to meet abnormal industrial and domestic demands. This can be explained by the fact that municipalities have suddenly fallen heir to many problems created by overtaxing existing utilities. We can assume, however, that the situation is not out of hand yet.

But what of the future if the war is unduly prolonged? Can municipalities be expected to enlarge their plants, maintain public health and extend sanitation to meet war-time conditions without government aid? If so, what will the financial aftermath be at the conclusion of the war? These are problems and questions to which the government should address itself and, if necessary, it should be ready to underwrite the cost of expanded services.

Emergency steps

So far this discussion has been devoted to the existing situation. Should the war zone extend to these shores, emergency conditions would be precipated. More thought, therefore, needs to be given to provisions for auxiliary equipment for meeting fire hazards, handling fractured water mains, providing emergency water supplies including interconnection with adjacent supplies and portable equipment for dealing with contamination. No time is more opportune than the present to evaluate carefully the problem of planning to meet abnormal conditions should they arise. Principal hindrances to effective action are the lack of first-hand information from the war zone involving emergency requirements, the difficulty of securing standby equipment, the widespread apathy which is manifest throughout the country due to the remoteness from the war area, and the question of cost. The latter, naturally, is being given the most consideration.

In Great Britain, many problems received attention for the best part of two years prior to the outbreak of war. Money expended in making emergency provision against air raid damage has been repaid threefold. Should we not profit by their experience and not wait for what *could* happen, but take all steps that are possible to guard against tragedy?

Trouble Shooters at Work

J. S. Longwell
Chief Engineer and General Manager
East Bay Municipal Utility District, Oakland, Calif.

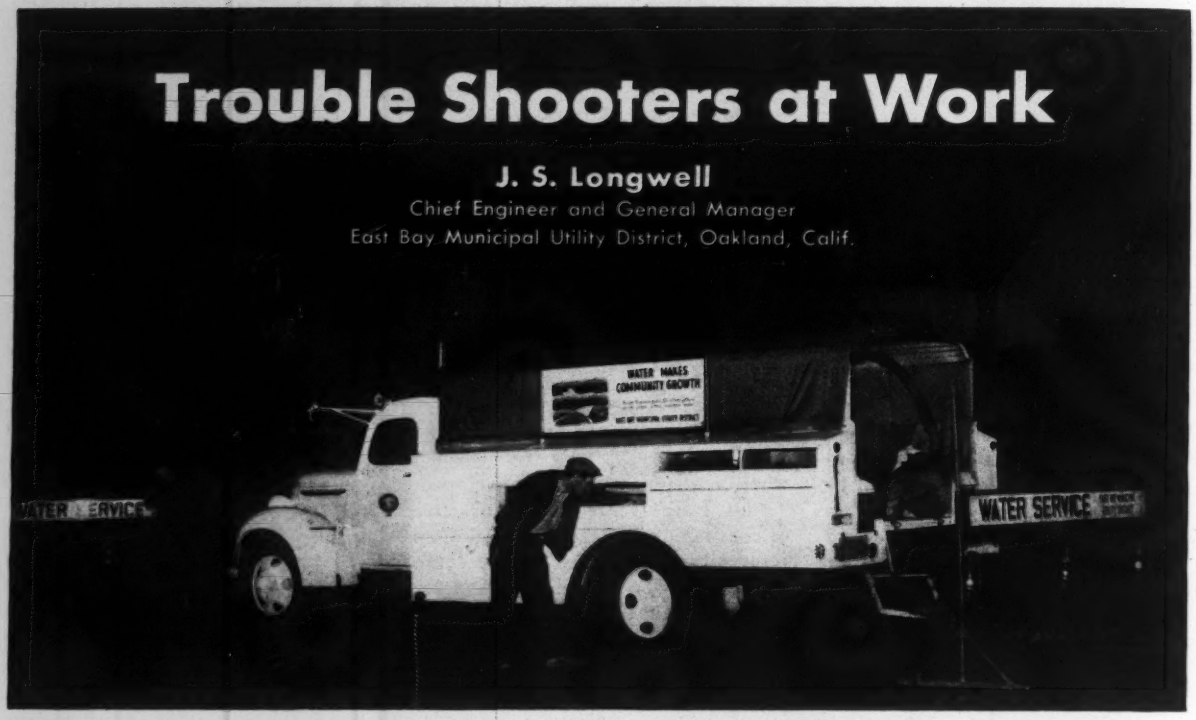


Fig. 1. Emergency truck painted white is used for night service calls.

***Contents in Brief**—Never before has there been a greater need for trained personnel, properly equipped, to handle maintenance and emergency service requirements. The organization, equipment and methods employed by the East Bay District may be useful for adoption elsewhere.*

EQUIPMENT, PERSONNEL AND PROCEDURES developed to handle emergencies call for special attention always. But today, with abnormal demands on water service, it is imperative that "trouble shooting" activities be designed to function at highest efficiency. The following outline of organization and procedure employed by the East Bay Municipal Utility District may be helpful to others engrossed with the responsibility of safeguarding supplies and providing for continuous service.

The East Bay District—comprising nine cities and an area of some 200 square miles—has made careful provisions for emergency service. The primary elements of the water system are the 93-mile aqueduct from Pardee Rerservoir on the Mokelumne River, five filter plants and four terminal reservoirs. A network of 1,800 miles of transmission and distribution piping is needed to serve the 540,000 people in the district. Furthermore, to provide proper pressure and capacity in this hilly country, the district operates 44 pumping plants, 23 reservoirs, and 45 tanks.

Emergency service operations which are described herein have been divided into two parts, namely, (1) those which pertain to the Mokelumne River system—including storage, the aqueduct and all features down to the terminal reservoir; and (2) the distribution division—beginning with the terminal reservoir and including the filter plants and the complete distribution system.

Along the aqueduct, a daily patrol is maintained with men traveling in cars along an operating road located on the aqueduct right-of-way. These patrolmen inspect the above-ground sections of pipe, air and vacuum valves, wasteways and miscellaneous structures and watch for any possible leaks in the buried sections of pipe. Maintenance forces stationed at Stockton and Lafayette take care of all necessary repairs and are available for handling any and all emergencies that may develop. The aqueduct pipe ranges from 61 to 65 in. in diameter except at the three river crossings, where it consists of two lines of 54-in. pipe. Extra sections of each size of pipe in 30-ft. lengths are kept on hand at five locations along the line for emergencies.

A portable welding machine and pumps for unwatering trenches are kept at the Stockton yard. Excavating equipment is available at the distribution division headquarters in Oakland. The latter includes a truck crane carrying a $\frac{3}{8}$-cu.-yd. clamshell bucket, one $\frac{1}{2}$-cu.-yd. power excavator equipped to operate as a dragline or a clamshell, and one $1\frac{1}{4}$-cu.-yd. power excavator operating as a clamshell, dragline or shovel. Two portable air compressors are also available. Additional welding equipment, air compressors, pumps and electric lighting sets are available from the Oakland yard on short notice.

An interesting and important feature for the protection of this aqueduct is the special type of automatic

wasteway, four of which have been installed. The steel pipe section of the aqueduct was designed to withstand internal pressures on the basis of the maximum hydraulic gradient with full flow but was not designed to withstand the full pressure from Pardee Reservoir. These automatic wasteways have been arranged, therefore, to shut off the flow through the aqueduct by means of a butterfly valve and at the same time to open a needle valve releasing the water upstream from the butterfly valve without increasing the pressure in the line. The discharge from this needle valve flows into sloughs or natural drainage channels.

Operation of this automatic device is as follows: In case of a break in the aqueduct downstream from one of the wasteways, the flow increases and causes a greater differential in pressure between the full section of the aqueduct pipe and the venturi section in which the butterfly valve is located. This change in differential, through a mercury manometer, closes an electrical circuit starting the motor which operates the butterfly valve. As the butterfly closes, the arm between the butterfly and the needle valve is actuated and it raises the needle valve, releasing the aqueduct flow to the wasteway. This prevents water being discharged for a long period at the location of the break with resulting damage to property and prevents any pressure increase in the aqueduct. Should power not be available for any reason, operation of these valves can be taken care of by hand.

Distribution system precautions

Successful operation of a large distribution system requires that all facilities be maintained in proper condition so that an adequate supply of water may be available at all points and at all times. This means that sufficient reserve storage must be on hand to take care of peak demands and to provide for all reasonable emergencies. Filtered water storage in the district's distribution system amounts to 317 million gallons or sufficient to last seven days, based on the present average use of 45 mgd. and sufficient to last five days during the peak of the summer season when the use will run 60 mgd. During the past two years this storage has been increased 20 million gallons; much of this is at high storage, which can be dropped down to the lower zones to supplement existing supplies should there be an emergency.

The entire supply for the higher sections of the district must be pumped up from the lower zones and for this purpose there are 44 pumping plants. These are electrically-operated with power furnished by the local power company, and most plants operate automatically. To avoid shortage of water in any of the higher zones, should electric power not be available, the district has assembled in its own shops a gas-engine-driven centrifugal pump with a capacity of 250 gpm. at 500-ft. head and at the rate of 460 gpm. at 200-ft. head. Special connections to mains, located at convenient points, are available to which the pump suction and discharge may be connected for pumping from one zone to the next higher zone. This unit is mounted on skids and is kept at the general yards and shops. In times of emergency it is placed on a truck and hauled to the location where the pumping is to be done.

Fig. 3. If a pumping station should go out of service, a gas-engine driven centrifugal pump unit mounted on skids is available. This unit has a capacity of 250 gpm. at 500-ft. head.

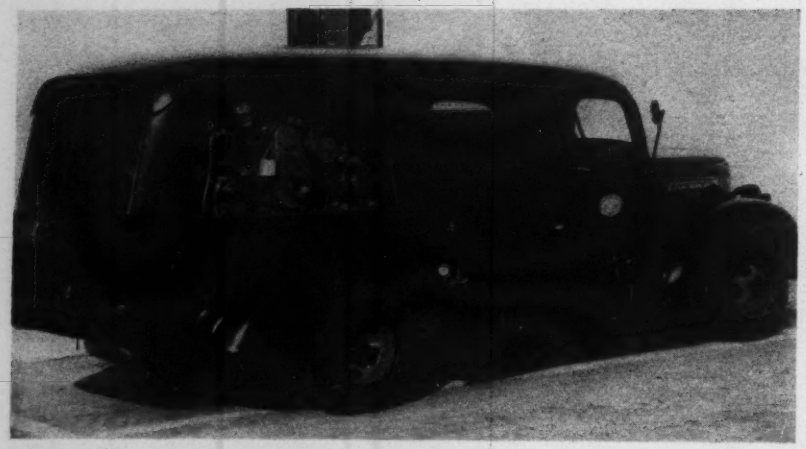
As further protection in case of power outage, a portable gas-engine-driven electric generator is now being assembled in the district shops capable of supplying sufficient power to operate a 100-hp. motor. This unit will provide power for lights and for operating washwater pumps and chemical feed equipment at the filter plants, and also for operating distribution pumping plants when no other power is available.

Service trucks and crews

Leaks and breaks occur from time to time in any distribution system and proper materials and equipment are kept on hand to make all necessary repairs. Service crews, available at all hours of the day and night, consist normally of one foreman and two to three men equipped with a special truck which was assembled in the district shops. In case of large breaks, the crew can be expanded by drawing on other forces, or several crews may be called out to handle the job.

The service trucks are covered and

Fig. 2. To handle leaks and breaks in the distribution system this service crew has a specially equipped truck on which an air compressor is mounted between the cab and covered section.



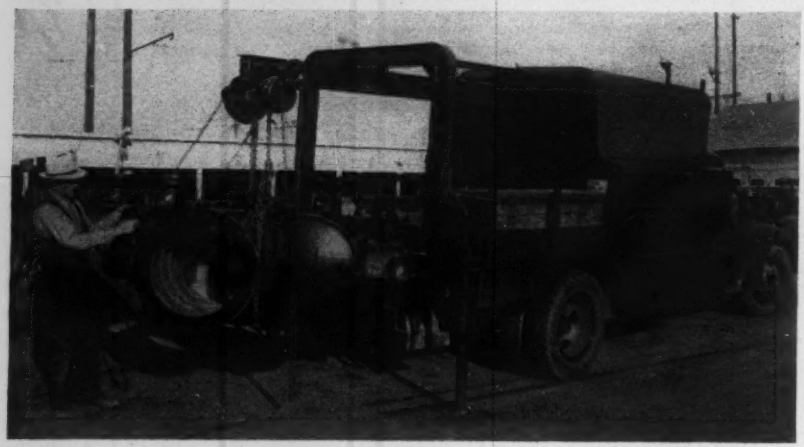


Fig. 4. Service trucks for special needs. At the top is a "traveling machine shop" with a gas-engine-driven air compressor and pump used in servicing pressure regulators. The lower view shows a trolley beam and hoist equipment fitted to a truck used for handling large valves and meters.

provide seats for carrying ten men. They carry all tools for unwatering excavated trenches and repair parts. In some cases a compressor has been mounted on the truck between the cab and the covered section to furnish air for operating paving breakers, digging tools and tampers. Where the truck is not equipped with a compressor, portable compressor units are provided as required and a sufficient number of these units are kept available to meet all requirements. In case gas or electric welding is necessary in the repair of steel lines, special welding units are available. These consist of a flatbed truck on which is mounted a gas-engine-driven electric welding machine as well as oxygen and acetylene tanks for cutting and welding.

In the East Bay District distribution system it is necessary to use many pressure regulators, and these are scattered throughout the entire area served. For convenience in maintenance a truck has been built, for use by the mechanic handling this work, and is equipped with all necessary tools and repair parts. It also carries a gas-engine-driven air compressor and a small pump driven by the same gas engine to remove water from regulator pits or manholes. This mechanic also inspects and services all double check valve installations for prevention of pollution of the public water supply from private sources of supply.

For handling large valves and meters and for carrying and using valve inserting equipment as well as equipment for tapping large mains under pressure, another special truck unit has been designed and assembled in the district shops. This unit contains an overhead trolley beam from which chain blocks are operated. In addition, space is available for the other special equipment mentioned as well as room for the "bull gang," the term generally applied to this group of a foreman and 3 to 4 men who are real experts in taking care of special and difficult installations and repairs.

Night maintenance crews are provided with trucks painted white as a safety measure. These trucks carry all necessary equipment for making emergency repairs to pipelines and services as well as special lights for night work.

With a large fleet of trucks and cars in operation continuously, it is necessary to provide for emergency repairs to this equipment. A tow car has thus been developed which is now being provided with a power take-off to operate equipment for opening and closing large gate valves.

An important feature in the operation and maintenance of any water supply system is its record of the location of all pipes and gate valves. Complete records are available and all foremen are provided with maps showing the exact location of all pipe and valves in their districts, giving sizes and designating those closed at zone lines.

The East Bay Municipal Utility District differs from many water companies or departments as to its source of supply, topographic conditions and other similar items, and its procedure in meeting emergency conditions, as outlined herein, has therefore been designed best to meet these special conditions. However, many of these conditions are common to all water systems and wherever water is furnished to a large number of people, to large industries and commercial institutions and to schools, universities and hospitals, it is necessary in the everyday run of things to see that all possible precautions have been taken for safeguarding the supply and for guaranteeing continuous service. When this has been done the operating organization is in a position to cope with almost any emergency that may arise without any substantial increase in personnel, equipment and supplies.

Personnel

Operation of the Mokelumne Division, which includes the Pardee Dam and reservoir and the Mokelumne aqueduct, is under the direct supervision of George B. Sturgeon, maintenance engineer. The distribution division is handled by J. D. DeCosta, engineer in charge of distribution.

Silent Sentinels of Service

Paul Lippert
Engineer of Pumping Station Efficiency
Department of Public Works, Chicago, Ill.

***Contents in Brief**—Control and recording devices of a great variety are now available to insure efficient operation of water systems. Where and how some of these instruments may be employed to special advantage is the subject of this article.*

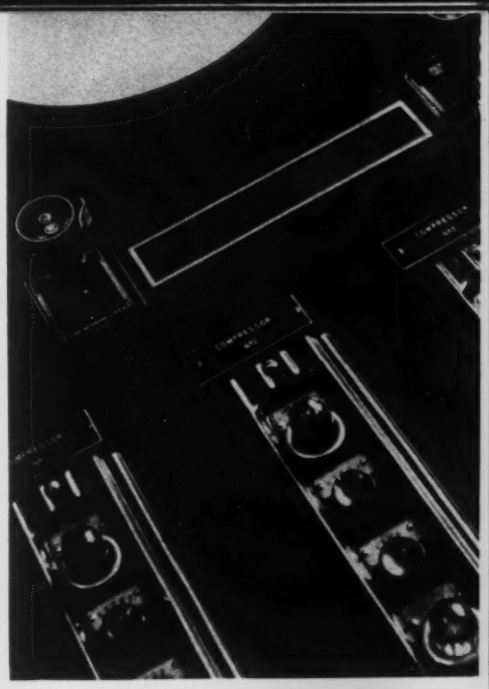


Fig. 1. Pushbutton control and visual indicators.

PERHAPS there has never been a time when indicators and control devices could be employed in the waterworks plant to better advantage. This is particularly true where dependence is placed on pumping equipment, the breakdown of which would cause a serious interruption in supply.

Occurrence of breakdowns can be minimized by the alertness of operating forces provided they are guided by a complete installation of essential indicators and instruments. Such devices really constitute a first line of defense, and they are essential elements in any program of preparedness. While good operation of pumping stations can be obtained with comparatively few controls, use of more elaborate instruments will lead to more efficient results. Furthermore, with the aid of printed records or charts it is frequently possible to obtain advance information of impending operating faults.

Probably there is no more valuable operating information available than that obtained from charts showing a continuous record of performance. If these charts are used intelligently they serve as an accurate operating guide as well as a true history of the condition of the machine.

What to use

In discussing the application of specific instruments to pumping stations it is logical to start with the elevation or well gage for recording the surface elevation of the source of supply. Such gages are of several types ranging from a simple counterweighted float, pointer and scale, to the complete indicating and recording instrument that operates by continuous compressed air or water; in the latter the recording mechanism usually is electrically-operated. There should always be in plain view from any part of the pumproom a large dial indicator; and an audible signal, which operates at the minimum allowed low level, is an important accessory. With the availability record of elevations of the water surface, many undesirable operating conditions can be avoided.

Connected close to the suction opening of the pump there should be a suction gage. For instantaneous readings the barometer type of manometer gage is by far the preferred instrument; it is very desirable, of course, that some type of recorder be installed which will record continuous suction values. Thus with the information provided by the well and suction gages, existing or impending operating faults are immediately made known and localized. Often it takes much more time to locate a fault than it does to remedy it, and the assistance given by the instantaneous or charted records as an aid in the work can hardly be overestimated.

The volume flow of the pump should be accurately and continuously measured, too. It appears that meters giving instantaneous, continuous and integrated values are the most useful and satisfactory types. Such a meter should have no moving internal mechanism but it should be provided with indicating and recording devices. To measure discharge pressures the best indication is obtained with a large dial Bourdon gage. A first-class recording pressure gage giving a continuous pressure or head record is of great value.

With the pumping units equipped as outlined, and with close attention to the indications of these instruments, it is obvious that the possibility of serious damage or breakdown is quite remote. Further, when the indications show impending or developing faults, it is possible to make repairs or replacements overnight or at periods of low demand, and thus prevent an annoying if not a dangerous supply interruption.

Electrical safeguards

When the prime mover is a motor and the plant or station is small, ample protection can usually be obtained with any accepted type of circuit breaker. The use of relays is desirable, of course, but not imperative in these small plants.

Power requirements are usually measured by the wattmeter of the utility furnishing the energy, but it is recommended that an indicating wattmeter giving instantaneous values be available. This is of special assistance not only as an indicator of normal or abnormal power requirements, but for test purposes as well. Proper use of the indicating wattmeter will give instant knowledge of impending or developing operating faults and thus reduce the probability of motor damage.

In large motor-driven stations a more elaborate system of indicating and recording instruments should be employed. The usual overload, under voltage, and at times, differential relays are necessary, and it is desirable that in addition to indicating, recording and integrating wattmeters there should be voltmeters and ammeters. Practically all large-motor driven stations operate at a high voltage and should be equipped with modern switching and circuit opening devices.

With an up-to-date arrangement of electrical control serviced by competent operators serious damage is well-nigh impossible. On the other hand, where a large station is not equipped with these instruments and protecting devices, a most rigid and alert operating system will often fail to prevent breakdown, due largely to delayed action that occurs where dependence is placed on manual control.

Steam power operation

To discuss the necessary indicators, instruments and control of large steam stations in detail would require more space than is available here. However, it should be noted that the boiler room of large steam-driven stations has been radically changed from what was considered acceptable a few years back, and there is probably no part of pumping station practice that has been more advanced in equipment and control or regulation than the boiler plant.

One of the most important items in boiler operation is the efficient burning of the fuel used. This is accomplished with comparative simplicity in the use of liquid fuels but requires a more elaborate arrangement where coal is burned on stokers. Combustion control is not a simple problem, and much depends on the integrity of initial designs.

Fig. 3. Switchboard and switching gear at the Cermak pumping station in Chicago. The control and safety devices cover almost every possible emergency.

There are certain features of all combustion controls that are of prime importance, such as the method used in transmitting the regulating power to the various controlling or regulating devices, the method of compensation (that is, the arrangement used to bring the control to a "dead beat" position) and finally, the ability of the system to meet a reasonable change in the combustibility of the fuel.

While it can be stated that reliable and accurate indicators, instruments and controls are truly silent sentinels of service, it must be recognized that these valuable aids must be competently serviced if the best results are to be obtained. These instruments can be most economically and correctly serviced by their makers, and it is false economy to permit the use of inexperienced labor on these intricate devices.

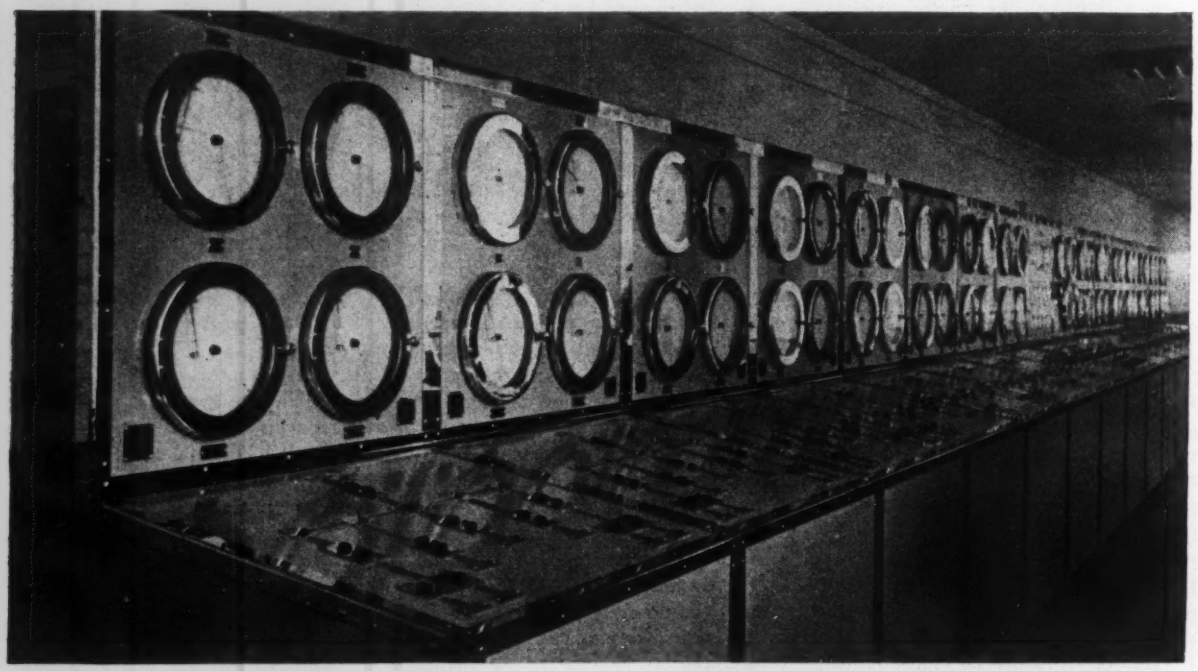


Fig. 2. Centralized control at the new filter plant in Providence, R. I. Loss-of-head and rate-of-flow recorders are mounted on the vertical section, with mimic piping diagram of filters and pushbutton stations on bench board section.

Interconnections Solve Supply Problems

Charles H. Capen
Engineer, North Jersey District Water Supply Commission
Wanaque, N. J.

***Contents in Brief**—Adjacent municipalities may find it to their advantage to consider "pooling" of supply resources by means of system interconnections. Experiences and recommendations from a study toward this end made in New Jersey reveal the advantages and the problems of such a plan.*

PROBABLY there is no populated section of the country where engineers have not studied water supply in sufficient detail to know possible needs as well as methods of meeting them. But physically to develop large supplies, or even additions to existing ones, requires time. And time is of the essence today to meet the accelerated demands of national defense activities. This is exactly the situation that has arisen in New Jersey, and the solution proposed is believed to be sufficiently typical to be useful in many other locations. Stated briefly, the method consists of connecting all sources of supply that may reasonably be joined so that these supplies may be virtually pooled for common usage.

Water supplies in New Jersey have had a history of turmoil and rivalry that may have been equaled elsewhere but is probably unsurpassed. Beginning about 1800, problems arising from location of sources, ownership, and intrigue have continued right up to the present. In northeastern New Jersey, where the situation is most aggravated, a population of nearly 3,000,000 people is served by 33 separate water sources, of which 23 are publicly controlled and 10 are privately owned. And this does not take into account the many wells and surface supplies utilized privately by industries. Water from 33 sources now totals nearly 300 mgd., and this is retailed by 70 separate organizations, each having its own schedule of rates. Under such conditions, it is inevitable that conflicts of interest should militate against the best solution of mutual problems.

High and dry are the normal intake pipes from this reservoir in New Jersey, during the 1939 drought. Conditions such as these offer a potent argument for interconnection of adjacent supply sources.

Interconnection plan

Foreseeing ultimate need for a more comprehensive and logical use of existing supplies, those instrumental in drafting legislation under which the State Water Policy Commission was formed in 1929 included the following provision:

> The Commission shall have power, upon petition or upon its own initiative, after hearing, upon notice, by order or in writing, to require the interconnecting of public water-supply systems, whether in public or private ownership, whenever the Commission determines that the public interest requires that such connection be made and to require the furnishing of water by means of any such system to another, upon fair compensation and reasonable rates and just and equitable terms to be prescribed by the Commission, such rates shall be subject to review and adjustment by the Board of Public Utility Commissioners.

Preliminary studies were advanced in 1929, with a view to making recommendations. Financial stringencies of the next few years, however, resulted in a cessation of all such activities. In 1936 the regional North Jersey District Water Supply Commission and the State Water Policy Commission cooperated for the first time and decided on joint action along several lines, the foremost of which was a study of interconnections. Within two months an application was made for a WPA allotment to aid in conducting the work of a survey. Failure to get approval by all parties concerned resulted in a delay of two years. Late in 1938, the

Ready to make a tie-in between sources of supply, which will assure adequate water for two neighboring communities.

legal and financial hurdles were overcome.

Active work was started in 1939 and a preliminary report was ready early that summer. As if to emphasize the importance of such an undertaking, Nature staged a drought of considerable proportions. Before the dry period was over, some supplies had to use, or construct, interconnections already pointed out as desirable.

The legislative enactment, mentioned in a previous paragraph, defines the term "interconnection" legally, as far as its use in New Jersey is concerned. It must be noted that this definition is at variance with that given by Goudey (and adopted tentatively by the A.S.A.). Nevertheless, the word "interconnection," throughout this paper, will be considered as a connection between any two supply systems, either at points on transmission mains or on distribution mains.

Such an interconnection is one that is primarily for emergency purposes or occasional use. When a connection is a normal channel of supply, in daily or frequent use, it has been termed a service connection.

Selecting connections

It is obvious that among any such conglomeration of supplies as exists in New Jersey, there must be a number of existing connections. Some of these are service connections and some interconnections. Altogether more than 300 existing or possible points of connection were located and studied in northeastern New Jersey. Field work consisted of conducting flow tests in adjoining systems and later making detailed surveys of points deemed essential as interconnections. Office work included computation and plotting of field records, and preparation of suitable maps and formulation of specific policies.

Finally, there were selected 32 points as desirable sites for interconnections. Ten of these were considered urgent and have been recommended for immediate installation. These do not include a few interconnections, which for one reason or another, have already been advocated by others and in some cases are under construction or are expected to be shortly. Hearings have been conducted to permit a discussion on the subject, but so far no pressure has been applied to expedite construction. The main stumbling block seems to be that of apportionment of the cost, difficulties which eventually will be overcome. Total cost of the 32 interconnections is estimated at $90,300.

In addition to these short interconnections, three trunk transmission lines, totalling several miles of large pipe, ranging from 42 to 60 in. in diameter, have been recommended. The cost of these is estimated at $2,000,000. They are so planned as to form an integral part of any large-scale network expansion that will be carried out in this area.

Other interconnections, considered less vital at present, are recommended for future attention. There are five of these which are classed as short interconnections, and three trunk transmission lines. Estimated cost of the former is $10,800, and of the latter, $1,138,000.

Two areas were studied in southern New Jersey, one in the vicinity of Camden and one around Atlantic City. The latter was found to have no immediate problem, but the situation in the Camden area is quite complex. There are 31 supplies in this region, of which 21 are publicly owned and 10 are privately owned. The gross output of these is about 32 mgd. and this is delivered to 62 separate municipalities. Some of the latter buy water at wholesale and for this reason, as in northeastern New Jersey, the number of retail organizations exceeds the number of supplies. The population served is about 400,000.

Acute conditions

Actually, the same type of problem exists here as in northeastern New Jersey. The difference is one of degree, rather than of kind. No better evidence of the acute condition that may arise could be afforded than that which attended the floods of September, 1940. A preliminary report had just been prepared when some of the supplies recorded as having inadequate facilities were forced to resort to extreme measures. In one case, a fire pumper with 1,400 ft. of hose line, supplied a municipality for two and one-half days. Installation of an interconnection between the two would have sufficed.

Five essential interconnections have been recommended for this area, the cost being estimated at $51,500. Ten future short interconnections and four transmission lines are advocated.

It would be fine to be able to report that these vital links in this chain of precautionary measures had been forged and put into use. Such is not the case, however. The same type of competition, jealousy and antagonism that has been responsible for creating the existing hodge-podge is now preventing the taking of the first logical step toward alleviating the conditions of the past. Until some state, or, if necessary, federal agency steps in and orders such work done, there is little likelihood of progress being made by amicable persuasion.

More Capacity with Clean Mains

Clinton Inglee
President, National Water Main Cleaning Co.,
New York

***Contents in Brief**—In numerous instances it has been demonstrated that inadequate supply and low pressures are traceable to reduction in the carrying capacity of pipe due to mud deposits, incrustation and tuberculation. Cleaning of mains may be the means of rejuvenating the system, even to the point of eliminating the need for additional pipe in the distribution grid.*

ONE OF THE PRIMARY REQUIREMENTS for defense manufacturing plants and for new housing developments adjacent to them is an adequate, continuous water supply. Defense activities have caused changes in population centers which in many cases were not anticipated when water distribution facilities were designed. To take care of such situations with extensions or supplementary lines is not always possible but there is one thing that can be done—the old lines can be placed in first-class condition by cleaning them and thus assure maximum delivery of water though existing mains. And the cost for cleaning is but a fraction of the carrying charges on capital investment in new or supplementary piping.

Recent European experiences show that in the bombing of water utilities the distribution system suffers more than either pumping or treatment plant facilities. Distribution system damage alone might not be so serious were it not for the fact that simultaneously fires occur and water is needed to fight this hazard. With sufficient valves properly placed, short sections of mains can be valved off when broken, the shut-off can be localized and water can be supplied by nearby lines and hydrants. For any fire fighting service the maximum capacity for delivery is essential, but in wartime it may be necessary to convey water through a long series of other mains and cross-connections to give service beyond the break. Thus it becomes even more important that every pipeline is in condition to provide maximum flow.

As an illustration of the necessity for adequate capacity consider the situation depicted by Fig. 1. Here the feeder main in a typical city block has been damaged by a bomb at *B*.

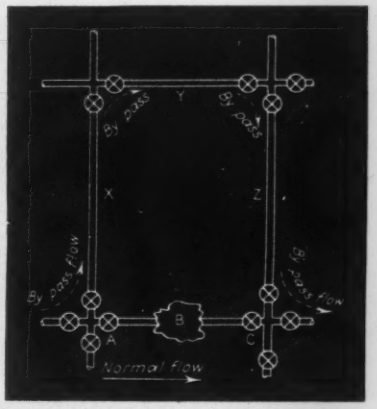


Fig. 1. Bypass arrangement which will work effectively only if pipes are of adequate capacity.

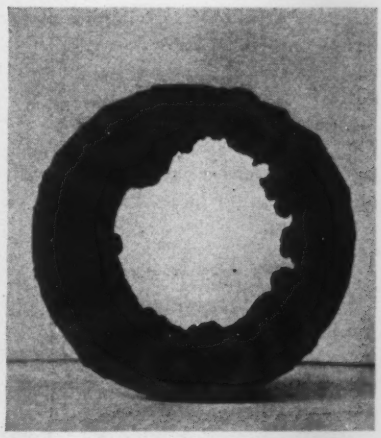


Fig. 2. Iron corrosion in an 8-in. pipe.

By closing valves at *A* and *C* it is possible to bypass the flow and continue delivery of water beyond the break. However, if pipes *X*, *Y* and *Z* are small in size or clogged with incrustations, the delivery of water would be impeded, and the bypass would be woefully ineffective.

Studies of coefficients by simple hydrant flow and pressure tests would indicate the condition of pipes and show where cleaning is required. This is preparation for defense which can be carried on inexpensively. And the far-sighted superintendent or engineer should plan now and have detailed instructions prepared for his men so that any damaged area, small or large, can be rapidly blocked off with a minimum interruption in service to all other areas.

Clean mains save money

With the huge expenditures for defense, tax burdens have been increased. Therefore, any measures which can be taken to effect economies in the operation of public utilities deserve consideration. Pumping water through dirty mains is costly and wasteful. It is surprising what economies can be had through the reduction of friction by cleaning.

Some examples of savings by reason of water main cleaning can be cited as follows:

A 12-in. line in California, 35,338 ft. in length, was reduced in capacity as indicated by a Williams and Hazen coefficient, C = 74. This line was cleaned, after which the coefficient was C = 121.3. At 2 mgd. flow, this increase in capacity would represent a theoretical saving of about 95 hp.

In a city in Texas, by cleaning an 8-in. line, it was possible to postpone the laying of an additional line for five years, thereby saving the city $1,000 per year on investment charges or approximately five times the actual cost of cleaning.

A small city in Georgia reduced its pumping expense $200 per month

Fig. 3. Propelled through a main by water pressure, the pipe-cleaning machine is ejected from a riser pipe at the end of its run; below is a view of the machine showing its cutting and scraping blades.

by cleaning its supply line, and out of this saving paid for the cost of the cleaning in six months.

In a small city in South Carolina, prior to cleaning its 12-in. raw water line, the use of a booster pump was necessary. After cleaning, 30 percent more water was delivered and no booster pump required. Information as to the actual dollar-savings is not available, but it was a considerable sum. And in one of Georgia's large cities, a program of pipe cleaning in one section of town secured 80-percent increase in hydrant delivery as evidenced by Fire Underwriters' tests. In table at right the first column lists pipe diameters, the second column shows assumed flows, and column three contains flow coefficient values representing average conditions for pipe in use many years. In column four is listed the theoretical power required per 1,000 ft. to pump water through a dirty main at the given rate of flow. Expected coefficients after cleaning are given in column five, and column six lists the required power for pumping. The last column shows the saving in power.

From a study of the accompanying table it can be seen that pipe cleaning not only may eliminate the need for booster stations, but will produce substantial power savings as a result of the reduction in pumping head or friction loss.

Cleaning is simple

Mechanical cleaning requires opening the main in two places. After the pipe is cut, a cleaning machine is inserted and the pipe is made up at the place of entry. At the other end of the run a section of pipe with a 45-deg. bend is set as a riser pipe to prevent washwater and dirt from entering the trench. The water is turned on to the proper pressure and volume to give the machine the required rate of travel through the main.

In cases where water pressure machines cannot be used, a cable is passed through the main by means of a special carrier or rods. After the cable has passed through, a cleaning machine is attached to it and inserted into the line. Then the pipe is made up, the water turned on to the proper amount, and the machine pulled through the main by means of a motor-driven windlass.

With either cable-drawn or water-propelled machines, a certain amount of water is allowed to pass the machine in order to carry ahead of it the dirt and incrustations which have been cut from the pipe lining and ground up by the machine. The water and this sediment and cleanings are carried to the street surface through the riser pipe. After the machine has passed through the main, the water is shut off, the riser pipe removed, and the main at that point reconnected.

The total time required for shut-off of water in any district is five to seven hours. In an emergency, the pipe can be made up temporarily and service resumed quickly.

Aside from economies that are evident in cleaning pipe, the time factor in getting more water should be considered. The need for greater quantities of water may well be so pressing that the restoration to full capacity of old lines is the only solution. It requires time to take bids, get materials delivered, and then to install new mains. A rehabilitation program, however, can be carried out with a minimum loss of time and an additional supply secured in a matter of days instead of weeks or months.

BEFORE AND AFTER

Power required for pumping through 1,000 ft. of pipe in mains of various sizes before and after cleaning

Pipe Dia.	Flow m.g.d.	Before Cleaning Coeff.	Before Cleaning Hp.	After Cleaning Coeff.	After Cleaning Hp.	Hp. Saving*
6 in.	1	60	26	110	8.5	17.5
8 in.	1.5	70	16	120	6	10
10 in.	2	70	12	120	4.5	7.5
12 in.	3	70	16	120	6	10
16 in.	4	80	7	120	3.5	3.5
20 in.	7	80	12	120	5.5	6.5
24 in.	10	90	11	120	6.4	3.75

*Divide by pump efficiency factor for actual saving.

Main Sterilization on a Defense Job

Henry J. Armbrust
Assistant Manager, Proportioneers, Inc.
Providence, R. I.

***Contents in Brief**—Continuous feeding of a solution of hypochlorite effectively sterilized water mains at the Quonset Point naval air station after difficulty had been experienced with the use of dry powder. The equipment and procedure employed on this important operation are described.*

DESPITE THE PRECAUTION of adding dry hypochlorite powder to each section of pipe laid in the water distribution system for the new Quonset Point Naval Air Station, bacteriological tests indicated the presence of contamination when the system was placed in use and samples were taken. This led to the decision to apply continuous chlorination at the source of supply so as to maintain a chlorine residual in all parts of the distribution network. As there has been much controversy concerning proper methods of main sterilization, it is interesting to review this recent experience at Quonset Point.

In the past, an accepted method of sterilizing mains has been to lay a small portion of dry hypochlorite powder in each section of pipe as the main is laid, in order to obtain a concentration of at least 50 ppm. of chlorine in the main when the latter is filled with water. Various objections to this method have been raised, such as the possibility of loss of strength of the hypochlorite when there is a relatively long period of time between the laying of the main and the filling; the impossibility of being sure that the proper amount of chlorine is in the pipeline when the main is laid in wet weather or in ditchwater; and the tendency of the water to wash the hypochlorite powder down to the far end of the main when the main is filled, thus forming a "chlorine plug" at one end and leaving the rest of the main with no residual whatsoever.

The method now being advocated by most authorities is the addition of chlorine—in the form of gas or as a solution of hypochlorite—to the water in proportion to flow while the main is being filled; thus each increment of water receives its proportionate amount of chlorine. Because of water pressure in the pipe equipment is required for introducing the sterilizing agent, and this equipment must be of such nature that the feed can be controlled accurately. Hypochlorination equipment lends itself readily to this work.

Water system facilities

Main sterilization at Quonset Point was complicated by the fact that the water system was already in use. The Air Station is provided with two water systems, one a portable supply and the other a salt water system for fire-fighting purposes. Salt water is used for the latter because of limited groundwater resources.

The fresh water system includes a gravel-packed well and motor-driven low-head pump, the latter delivering water through an 8-in. asbestos-cement main to a concrete-covered reservoir. From the reservoir the water is pumped into the asbestos-cement distribution pipe network which is connected with an elevated steel tank. Before the booster station, tank and reservoir were completed, a temporary gasoline-driven booster pump was employed, and the salt water storage tank was pressed into service pending the completion of the elevated tank. A portion of the distribution system was in service while new sections were being added.

Although the well water was satisfactory from a bacteriological standpoint, and the precaution was taken to place a quantity of dry hypochlorite powder in each length of pipe, samples of the water taken at the barracks and other points in the system showed the presence of undesirable bacteria. Since the roads on the reservation had not been surfaced nor had they time to settle properly, it is believed that the movement of heavy

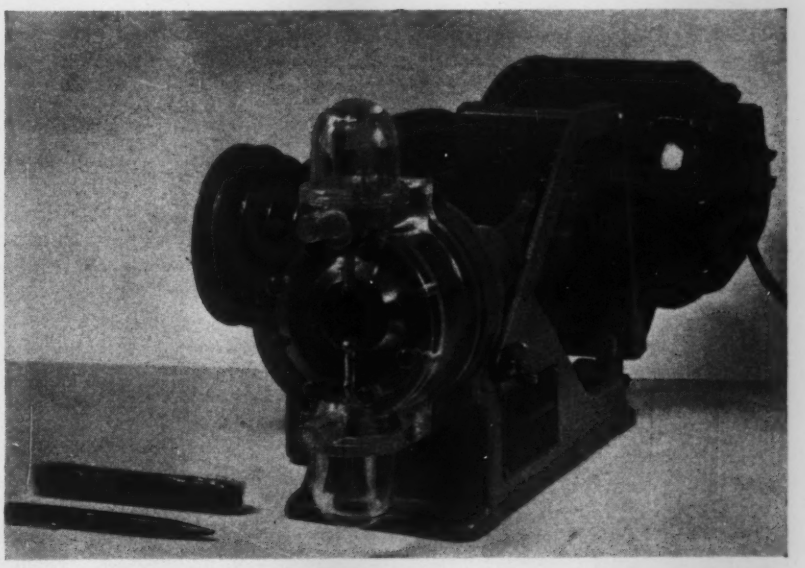


Fig. 1. Mechanical feeding unit that was used for continuous injection of the hypochlorite solution into the system.

equipment caused some breaks in the mains which led to contamination. It was decided, therefore, to chlorinate the supply so as to maintain continually a safe chlorine residual in all parts of the system.

Plan of action

The writer's company was called and arrangements made for immediate installation of a hypochlorinator, with the understanding that if a satisfactory residual could not be maintained throughout the system or if the chlorinous taste were too strong, a second feeder for aqua ammonia would be installed so that chloramine treatment might be used. Originally it was thought that the best plan would be to make temporary installations at various points on the main and to treat one section of the system at a time. This plan was abandoned in favor of continuous treatment at the source, for the following reasons:

(1) Breaks might occur for some time to come and it would be necessary to set up the equipment and sterilize over again.

(2) By feeding a sufficiently high dose, continuous sterilization could be accomplished which would take care of almost any condition which might arise.

(3) Once the equipment was properly set up and the desired residual obtained, a non-technical man available at the station could be used for opeating the equipment under occasional supervision.

(4) Previous experience with continuous chlorination at nearby Providence, R. I., gave excellent results. (See *Water Works Engineering*, Feb. 14, 1940.).

A heavy-duty hypochlorinator was installed in the low-lift pump house and connected so as to feed into the discharge line from the pump (Fig. 2). Based on the rated capacity of this pump and also the booster pump which was in tandem, the equipment was set for a dosage heavy enough to produce a residual chlorine value of about 0.5 ppm. Residual tests were then made at the booster pump some 2,000 ft. away and a number of taps were left open at the barracks to insure circulation through the distribution system.

About one-half hour after the chlorinator began, the first residual test was made at the booster pump, but no residual was found. Another

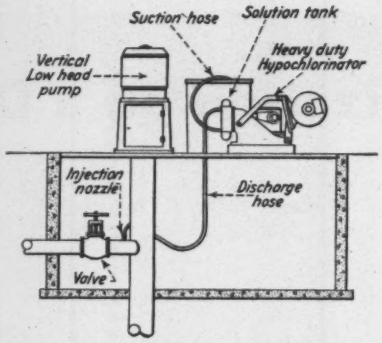


Fig. 2. To provide continuous sterilization of the mains the hypochlorinator was connected so as to feed into the discharge line from the pump as shown above. Regulation of chlorine dosage was accomplished by varying the rate of feed of the chlorinator in relation to pump discharge.

test fifteen minutes later likewise was negative. It was not until an hour and a half later that a residual of over 1 ppm. appeared at the booster station. Surprisingly, there was no chlorinous taste associated with this comparatively high residual found in the water.

In view of this lack of unpleasant taste, it was decided to maintain the feed as was. At the present writing the equipment has been in operation nearly two months and no taste has yet developed. Incidentally, it was found that while the booster pump was rated at 350 gpm. at 1,750 rpm., the gasoline motor used to drive the pump was in such condition that the pump man operated it at less than 1,000 rpm. and the delivery, therefore, was very low. This accounted for the delay in obtaining the residual.

Conclusions reached

Present plans are for maintaining the hypochlorination equipment in service until the entire water system is complete and then keeping it for use in case of emergency. From the above experience, the following conclusions may be drawn:

(1) Use of dry hypochlorite in the mains did not serve its intended purpose and is at best a make-shift and undependable method of main sterilization.

(2) Continuous feeding of a solution of hypochlorite with the possible feeding of aqua ammonia for the production of chloramines offers a convenient, reliable means of main sterilization which will enable a water system to be used during the sterilization process.

(3) Continuous feeding of a sterilizing dose of hypochlorite can be accomplished efficiently by the non-technical pump operator usually available at almost any water treatment plant.

(4) The maintenance of a sterilizing residual of chlorine or chloramines is an efficient safeguard against contamination which might be maintained by accident or possible sabotage.

The work was carried on under the supervision of Commander R. V. Miller, C.E.C., U. S. Navy, E. W. Hammer, project manager, and D. McGorrisk, assistant project manager for George A. Fuller Co. & Merritt-Chapman & Scott Corp., the contractors on construction of the Quonset Point Air Station.

A. B. Coulters and the writer represented Proportioneers, Inc., who furnished the sterilizing equipment and special supervision.

Extra Valves Minimize Water Interruptions

Guarding against serious interruption of water supply through accidental or deliberate breaks in the mains, WPA workers in New York City are closing up the gaps between shut-off valves in old lines and installing valves at 1,000-ft. intervals in new mains under the direction of the Department of Water Supply, Gas and Electricity, according to Irving V. A. Huie, WPA administrator for the city.

The valve installation is part of the program for normal improvement of water supply facilities, but it will make some contribution to defense through giving added protection from flood and fire. It is said that New York at present has more fire hydrants and shut-off valves than London had at the outbreak of the war, in spite of the much larger area of the British metropolis.

Additional distribution mains which WPA is now installing are from 8 to 20 in. in diameter and are provided with shut-off valves every 1,000 ft. Also being installed are some roundabouts, or connections between mains, through which water may be bypassed in case of a break in one of the mains, thus minimizing service interruptions in the area affected.

Distribution System Diagnosis

Edgar K. Wilson
Chief Engineer, The Pitometer Co.,
New York, N. Y.

***Contents in Brief**—Specific information concerning leakage, valve operation, the need for additional mains and the correction of errors in pipe records, may be obtained from a survey of the distribution system. Some surprising things which have a vital bearing on waterworks preparedness may be revealed by such a "diagnosis."*

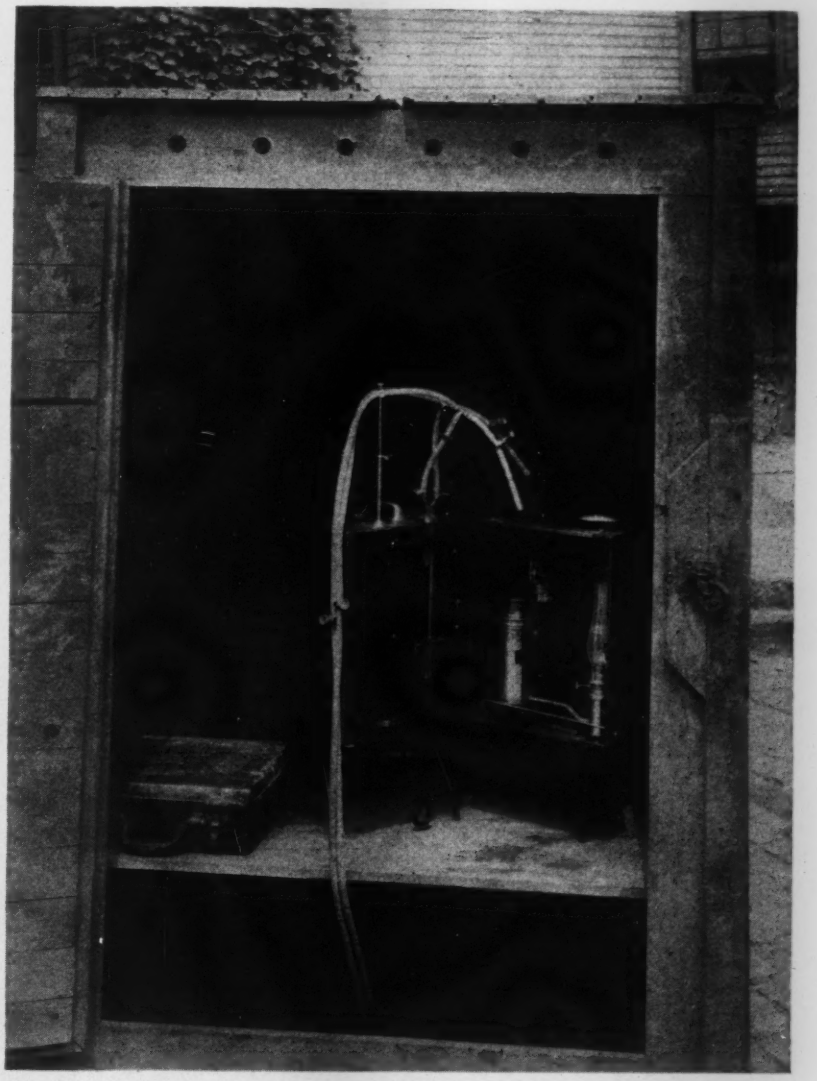
UTMOST EFFICIENCY in waterworks service is more than a goal in this hectic period of defense preparation —it is a necessity if industry and community life are to function with maximum usefulness. An evaluation of a waterworks system to discover and eliminate weakness calls for a three-point examination directed towards (1) an investigation of pump efficiency; (2) a survey of distribution system leakage; and (3) preparation of a long-range study of distribution system needs and replacements.

In making an investigation of a pumped supply, it should be remembered that the primary item of expense is operation of pumping equipment. If all the water pumped is passed through a master meter, the readings from this meter will reveal whether reciprocating pumps are slipping or the electric units are operating at their proper efficiency. A pump slip or unduly low efficiency of electrically-driven units means that the pumps are churning a part of the water without advancing it on its course, thus adding to the cost of pumping. Defective valves in reciprocating pumps or worn impellers on centrifugal pumps should be repaired to restore the pumps to their proper efficiency.

Tests of pumps often indicate that equipment is being used that is not adapted for the use to which it is put. Changing to a pump designed specifically for the service required will result in considerable economy and more satisfactory performance. To avoid possible error in tests using the master meter, pitometer measuring devices may be usefully employed to check both the meter and the pump performance.

Next to pumping equipment, major consideration should be given to the distribution system. Again, the master meter will be of service in determining the relation between total daily consumption and the minimum night rate. This relationship is of importance in determining whether the night rate of flow is unduly high, which would indicate leakage or waste during the hours when consumption should be at the lowest point.

While the general relationship for the entire system can be obtained



Pitometer photo-recorder device set up for distribution system testing.

from the master meter, in a system containing more than a limited mileage of pipe it is preferred practice to divide the area into small districts by closing boundary valves, and to measure the 24-hr. consumption in each by means of a pitometer. This intrument, operating on the pitot tube principle, can be easily and quickly attached to a pipe through a one-inch corporation cock set under pressure at any desired point, and it will measure the velocity of the water at the center of the pipe. From this measurement the total quantity of water passing the gaging point may be quickly computed with the aid of tables of velocities and quantities.

After the 24-hr. measurement is completed a night subdivision of the district is made by closing off each block of the district for a short period and observing the pitometer changes. In case of a change in the deflection some flow into the specified block is indicated; this may be a leak, legitimate use or unauthorized consumption.

Waste water survey

To make a proper water waste survey, subdivision of the system is of utmost importance, since only by this means can the water in each block be measured and the total night rate accounted for. An inspection of the pitometer records will at once indicate those blocks on which no further work is needed, while those which show an abnormal flow will require further investigation.

Elimination of leaks contributes to greater efficiency in other ways, too. Where the arterial feeders are heavily loaded, the stopping of leaks may defer the time when replacements or other reinforcing plans must be undertaken. Furthermore, water treatment facilities are relieved of part of their load, and there is a reduction in pumping expenses.

An important byproduct benefit derived from a thorough water waste survey is the inspection of valves of which 80 or 90 percent are operated in the course of the survey. In each valve operation the condition of the valve, number of turns required to open or close it, direction of operation and map corrections are recorded so that elimination of faulty conditions may be effected and quick action assured when an emergency arises. Often valves will be found closed, which seriously curtails the amount of water available for fire protection; and frequently valves that have been broken in operation and left unrepaired are discovered. Such revelations assist operating crews in performing a better job, and in many ways improve system efficiency.

A distribution system diagnosis invariably discloses leakage. Here is shown a split main which silently discharged 50,000 gallons daily before it was discovered.

Planning for the future

It is unfortunate, but true, that in a large number of our water systems little foresight has been used in planning for future requirements. Only on rare occasions is an engineer given a free hand to design a system completely from start to finish. Usually a community starts with a small distribution system and later additions are made with the smallest sized pipe which would care for the immediate needs for the area under consideration. Finally, extensions are added to these already inadequate mains with unfortunate results as to pressure and capacity distribution. Possibly the worst feature of this procedure is the preempting by undersized pipes of the most logical routes for feed mains; this leaves the alternatives of costly replacements or the selection of awkward and often much longer routes for installation of arterial mains.

The once popular method of designing extensions with nothing more than a red pencil and a blueprint is antiquated today. Only by analyzing a system as a whole and then studying it in sections can decisions be made properly to care for domestic consumption and fire protection. A distribution study should start with an analysis of the population and probable shifts in relation to changes in demand on arterial mains. Such studies are made on the basis of past population, school census, telephone and public utility estimates, and a thorough inspection of various facilities such as railroads and other transportation media which might influence the establishment of manufacturing plants. Probably the most enlightening study in this diagnosis is the investigation of available fire flows throughout the community. These tests simulate fire demands and show the results on pressures when several fire streams are flowing from a group of hydrants. An undue drop at the control hydrant clearly indicates the need for reinforcement either of the arterial system or the distributing mains.

All important feeder mains likewise should be investigated for loss-of-head, a condition which reflects carrying capacity. Such an investigation also shows which mains are carrying more than their share of the load, as well as those which are functioning properly. Mains which are not carrying their share of the load may often be strengthened by inexpensive connections or arrangement of valves, thus saving large sums which would otherwise be required to provide adequate feeder capacity for the system.

A study of the arterial system frequently reveals very peculiar facts as to direction as well as amount of flow; and these data, properly used, may be the basis for much greater efficiency for this important part of the water system. From such a study it may be found that replacements of additional feed mains will be necessary or that comparatively inexpensive cleaning may restore carrying capacity sufficiently.

Correction of various faulty conditions throughout the system, which may be arranged to cover progressively a period of years, permits important improvements to be made in time to anticipate needs and yet not so early as to require needless expenditure of funds for interest charges. To accomplish this successfully a master plan of improvements should be drafted and used as the basis for a work program.

Water For Fire Fighters

***Contents in Brief**—Industrial expansion places a prime obligation on municipal water authorities to extend and strengthen facilities for fire protection. From the specialized experience of the National Board of Fire Underwriters come these important suggestions on how to prepare for adequacy and reliability of service.*

NOT MORE THAN THREE DECADES AGO it was conceded that fire protection for high value property districts in our larger cities required many powerful water streams and that these could not be delivered by fire apparatus then in service. Installation of special fire main services was the answer in this need. Since then the automobile fire engine pumper has been developed to great effectiveness and fire-fighting practices have been improved. Today, the installation of separate fire mains is seldom justified in cities not now having them. The money required for this purpose can be used to greater advantage in providing better adequacy and reliability of existing water supply systems.

This is the conclusion reached by the National Board of Fire Underwriters, whose committee on fire prevention and engineering standards recently issued a memorandum (*Bull. No. 116*) to fire department officials on the subject of water supply. Much in this memorandum is of special interest to waterworks authorities, and portions are here extracted with the permission of George H. Booth, chief engineer of the board.

Measuring adequacy

What constitutes adequacy of water requirements for fire service is a matter related to several factors. First, there is the question of what constitutes a good fire stream. Some years ago this was defined as one of 250-gpm. discharge. For inside lines to be handled by one or two men, this size of stream is about correct, and for the usual type of residential or small store occupancy, it is reasonable to base requirements on the number of 250-gal. streams that may be needed.

Actually, present and future practice will be to use more and smaller streams for fire-fighting in this class of occupancy. Introduction of the automobile pumper in fire service has brought about a material increase in fire demand upon waterworks adequacy. A 1¼-in. stream, such as would be used as an outside line where a large building was involved, uses from 310 gal. at a 45-lb. nozzle pressure, which gives a reach of about 70 ft. of solid stream, to 350 gal. when the nozzle pressure is 60 lb. and reach is about 80 ft.

There is today a growing appreciation of the value and use of large streams too strong to be handled by hand. Fixed and portable turret or monitor nozzles are becoming standard equipment in small fire depart-

Wide World photo

Fire fighters today lay emphasis on the value and use of large water streams too strong to be handled by hand. Effective use of turret and ladder-type nozzles, which produce powerful streams, depends on the availability of water.

ments. The English are finding, in their almost daily occupation with conflagrations caused by bombing, that the use of ladder-type nozzles is one of the most effective means of preventing the spread of fire. These various devices for producing powerful streams add further to the demands on water supply adequacy. They provide more ready means for the use of the full capacity of the pumping engine in the fire department. Through the use of 3-in. hose and of siamesed lines of 2½-in. hose, 1½-in. and larger, nozzles can be used effectively. These give discharges ranging from 500 to over 1,000 gpm.

Even where great congestion of buildings is not present, it appears reasonable to expect at least two fixed powerful streams to be used on a fire which is threatening to spread to other buildings. These would be in addition to eight or ten hand lines. Using as an average, 600 gal. from the fixed nozzles and 300 from the hand lines, we get 3,000 to 3,600 gpm. as a minimum requirement.

Hydrants and mains

Adequacy is not just a question of total supply of water which will be delivered to the district under consideration; it depends also on whether there are enough hydrants to permit the water to be put on the fire without excessively long hose lines. A study made by the National Board of Fire Underwriters has indicated that hydrants should be spaced upon an area-served basis rather than upon linear spacing of hydrants. The figures decided upon are shown in the accompanying table.

Adequacy is also controlled somewhat by the size of the distribution main. The average fire department pumper has a capacity of 750 gal. This flow through a 4-in. pipe produces a friction loss of about 20 lb. in 100 ft. Even if the 4-in. pipe is fed from both ends, the friction loss is 5 lb. per 100 ft. and, since many blocks are 400 to 600 ft. long, a hydrant in the middle of a block would not receive an adequate supply if the pressures are reduced generally—as they will be in a big fire—below 20 to 30 lb. This is so because there is also friction loss in the hydrant branch, the hydrant and the suction hose. In many cases hydrants installed 20 years or more ago were of poor design and had a high friction loss, which seriously restricted delivery. Replacement of small pipes and hydrants in high-value areas should be one of the objects of careful study.

It is not uncommon, in the normal growth of a city, for the character of a section to change materially. Often sections that formerly were occupied by well-spaced single-family dwellings not requiring large quantities of water, either for domestic or fire service, will become closely built with multi-story apartment houses. These will result in lowered pressures and inadequate fire flow and generally there will be a deficiency in hydrants.

Other residential areas may change rapidly to a heavy industrial district. Under these conditions the needs of the area, as applying to the quantity of water, will be greatly increased. Many manufacturing plants, because of the size of the building and the nature of the contents, require quantities of water in excess of that supplied for a business district. Fire flow requirements of 8,000 or 10,000 gpm. are not unreasonable if these manufacturing plants are grouped.

In connection with adequacy of supply the question of pressure may be a vital one. Today the installation of automatic sprinklers is becoming very common. It is now recognized that the supply to these sprinklers can be taken from the municipal mains without providing for a secondary supply. On this basis it is essential that normal pressure be such as to give 15 lb. on the top line of sprinklers when 250 or 500 gal. is flowing.

Engineers of the National Board of Fire Underwriters have found fire flow tests to be of great value in determining adequacy of fire supply in various parts of a water system. These tests, which are discussed in *Bulletin No. 42* issued by the board, can be applied by any water department. In some cities, the water department has undertaken a definite plan of running tests in areas thought to be weak and of laying mains to bring the protection up to that considered desirable.

AREA-SERVED BASIS FOR HYDRANT SPACING

Recommended by the National Board of Fire Underwriters

Fire Flow Required (Gal. per min.)	Average Area Per Hydrant—Sq. Ft.	
	Engine Streams	Direct Hydrant Streams
1,000	120,000	100,000
2,000	110,000	85,000
3,000	100,000	70,000
4,000	90,000	55,000
5,000	85,000	40,000
6,000	80,000	40,000
7,000	70,000	40,000
8,000	60,000	40,000
9,000	55,000	40,000
10,000	48,000	40,000
11,000	43,000	40,000
12,000	40,000	40,000

A check on reliability

Reliability of water supply is of vital importance in connection with fire fighting. A check on the factors affecting reliability starts with questions as to whether anything can happen to the source of the water supply and extends throughout the system to the actual hydrant in use. Some of the more important failures which have taken place are here mentioned to give some idea of what may happen. This may be helpful in making a study of the water system and determining what action should be taken if shutdowns should occur.

Today many pumping stations are being changed over to electrical operation. Recent experience has indicated that the electrical companies have not in all cases provided the reliability needed for total dependence. As instances of this are the record of serious failure of electrical supply in recent years in Newark, N. J., Jacksonville, Fla., New York City and Buffalo, N. Y., where large parts of the city were without current for a number of hours. Had the supply works depended entirely upon electric power, a grave situation would have resulted.

Broken mains are probably the most common source of trouble. These often leave extensive areas without water and always result in a material reduction of pressure. In some cases the break may be in a single main which supplies the city, or the break may flood the pumping station or may undermine adjoining water mains. The location of pipelines, with respect to side hills, rivers, railroads and like features, is to be considered in studying the probability of interruption of supply.

Even the matter of design of the hydrant must be considered; many of the older ones, if broken off, will flow and this waste of water may materially reduce protection. Elevated storage, either in reservoirs or tanks, is of material value as offsetting many of the features of unreliability which may exist in the water system Such storage also provides for greater economy of operation of the supply works.

From Field and Office

Working problems and time-saving methods for engineers and contractors

Graph for Talbot's Formula

Talbot's formula for structure openings is presented by the accompanying graphs in convenient form for easy and rapid use. The graphs include drainage areas from 1 acre to 10,000 acres in flat, rolling, hilly and mountainous country. The use of logarithmic paper in plotting offers two distinct advantages: first, the lines are straight, and thus easily followed and read; and second, the smaller areas, say less than 1,000 acres, can be read to 0.1 sq. ft. of opening, while on the larger areas, where such accuracy is superfluous, the space is used to cover a large range of acres.

Suppose the user wishes to find the square feet of opening needed to accommodate a rolling drainage area of 20 acres. On sheet No. 1 in the left hand column, 20 is found. The heavy line subtending 20 is followed horizontally until it intersects high or low rolling as the case may be. The vertical line is then followed to the top of the sheet and the square feet of the opening is then read. In case of 20 acres high rolling, the square feet of opening is 4.7. The chart indicates that a 30-in. pipe is sufficient to carry the water.—BILL TURNER, *senior designer, Tennessee Highway Department, Nashville, Tenn.*

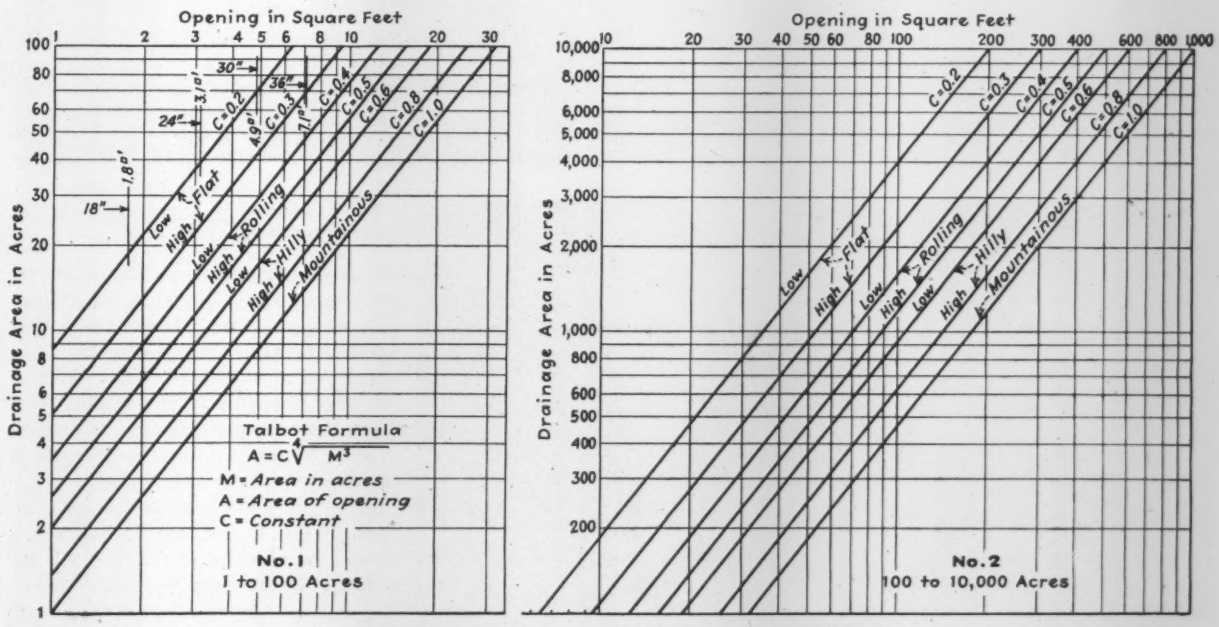
Automatic Gate Control

Regulation of flow level in the head canal that takes water directly from Kings River for the Consolidated Irrigation District is being successfully accomplished by the control arrangement shown by the accompanying schematic diagram. Kings River, fed by melting snow, is subject to daily and even hourly variations of flow that require constant head-gate changes to preserve a controlled canal level. To meet the difficulty of getting alert and exact control by hand-operated gates the writer devised the float-actuated, electric-power gate mechanism which was first installed in 1923 and has since been in operation 24 hr. a day during the irrigation season.

The headworks of the canal located near Centerville, Calif., consist of ten 4x10-ft. radial gates operated by worm-geared windlasses. Four of the gates are geared for hand operation; the remaining six are operated through gears on a line shaft driven by a reversible 1-hp. electric motor. A small reduction gear is used to give the line shaft proper speed. The control switches and relays are standard equipment.

It will be seen from the diagram that the actuating unit of the control system is the usual stilling well with float and rod. This well is indicated at *A* on the diagram. Well *B*, also shown, is the regular watermaster's gage and is no part of the control mechanism. The stilling well for float control consists of a 3-ft.-dia. concrete pipe connected with the canal water by a 1½-in. galvanized pipe. Centered in the concrete pipe is a 10-in. galvanized iron casing which acts as a guide for a copper ball float carrying a ½-in. galvanized pipe rod. A metal arm, which slides on the rod and is held by a thumb screw, carries two contact points which engage with two stationary contact points and complete the circuit that opens or that closes the gates as the float falls or rises. The thumb screw permits the sliding arm to be adjusted to the height of the canal water level desired. The stationary contact points are supported by a hard fibre disk set in the 10-in. casing; a hole in the disk is a guide for the float rod. All points are stock tungsten contact points.

Control is not exercised directly from the stilling-well contact points.



Graph giving area of opening by Talbot's formula for watersheds of from 1 to 10,000 acres.

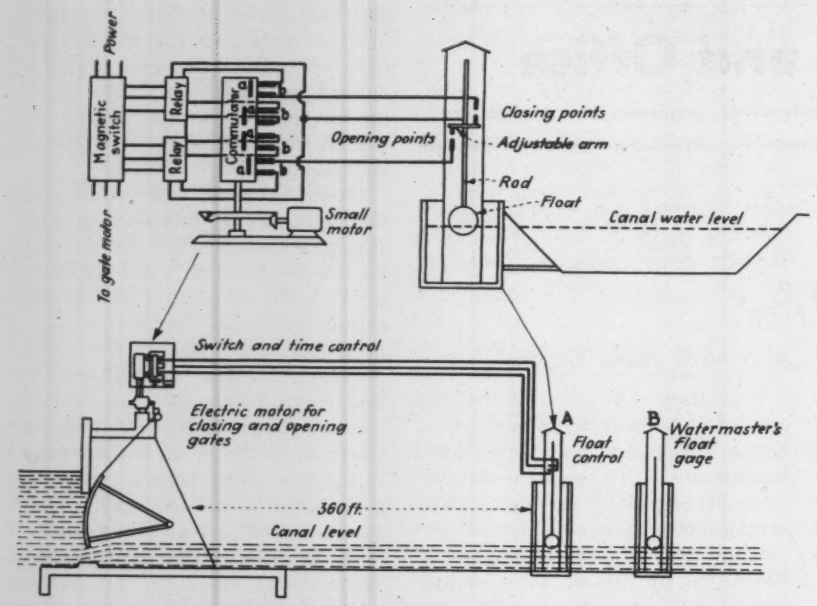


Diagram of automatic electric control mechanism used on canal inlet gate to regulate the flow level.

Since it is about 3 min. from the opening or the closing of the gates before the change in canal water level is registered by the stilling-well float, such direct control would result in excessive water-level changes and surges in the canal. To avoid these a time control is introduced between the stilling-well and the magnetic switch that operates the gate motors. This time control consists of a motor-driven shaft on which are four fiber disks carrying brass bars *a* which, as the shaft revolves, contact the brushes, *b*, wired in series with the well float contact points. The disks make a revolution every 3 min. and the contact bars are so spaced that the gates operate 10 sec. at 3-min. intervals until the stilling-well float registers required canal water level breaks the contact, and stops gate operation.—I. H. TEILMAN, *Chief Engineer, Consolidated Irrigation District, Selma, Calif.*

Speedy Pressure Tests For Seamless Tubing

Some 1,200 miles of electrically welded seamless tubing of 1-in. outside diameter to be used for circulating cooling water in Shasta Dam is being tested on the job for flaws that might cause leakage. To avoid taking imperfect tubing out on the dam, a testing rig is used at the Coram freight depot where the tubing is unloaded from railroad cars. As high as 5 percent of the tubing has been found defective in some shipments.

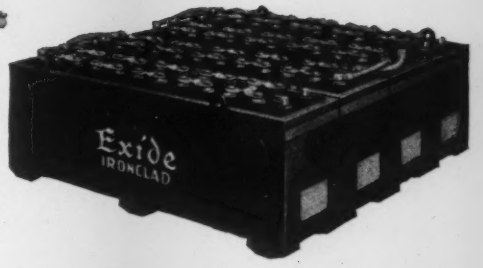
The tubing comes to the job in

Fig. 1. (Below) 1,500 lengths of tubing are pressure-tested on this rig in 8 hr.

Fig. 2. (Above) A speedy test rig for 90- and 180-deg. tube bends.

20-ft. lengths and to permit a crew of two men to test 25,000 to 30,000 lin. ft. per day, a simple bench rig is used which requires only the throw of a lever and opening of a water valve to subject a length of the tubing to a water pressure of 150 lb. per square inch. One end of the tube length is pressed against a rubber stop while a lever puts pressure on the opposite end by means of a cap through which water is admitted. A similar rig for testing bends is in use with adjustments to adapt it to either 90 or 180 deg. bends which are standard.

KEEPING ALL THE WHEELS TURNING FASTER



Exide-Ironclad Batteries underground help you feed more materials to industry

A HEAVIER STREAM of minerals moves faster from mine and quarry to America's hungry industries, when your underground haulage system is running swift and smooth. Exide-Ironclad power in your trammers or locomotives keeps all wheels turning faster under today's heavier loads.

This is because Exide-Ironclads have tremendous power, which they deliver at a voltage that insures good haulage speeds. In addition, they are so rugged that they stand up in the fastest, toughest service, giving no trouble, needing no repairs.

This is the type of dependability which enables you to take full advantage of Exide-Ironclad power in speeding up your own underground haulage service . . . safely and economically. It explains why more Exide-Ironclads are used underground than all other batteries combined. Write for free booklet, "The Storage Battery Locomotive for Underground Haulage."

Exide IRONCLAD BATTERIES

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia
The World's Largest Manufacturers of Storage Batteries for Every Purpose
Exide Batteries of Canada, Limited. Toronto

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

HIGHWAY AND BRIDGE, OHIO

OWNER: Ohio State Highway Department, Columbus, Ohio.

PROJECT: Grading, drainage structures, reinforced concrete and monolithic brick paving Sections Athens E and C-1 of State Highway 155, Athens County, Ohio. Also involves construction of steel beam bridge over Sugar Creek, three spans of 32, 40 and 32-ft., respectively. Bridge roadway width 28 ft. Entire project is 2.726 miles in length. Width of roadway varies from 24 to 48 ft.

CONDITIONS: Contractor to furnish all materials and complete work by July 31, 1942. Rail and highway transportation facilities available. Wage rates are: skilled labor, $1.00 to $1.50 per hr.; semi-skilled, 60c to $1.25; and common, 50 to 55c.

BIDS: Two bids were opened April 29, 1941, the contract low of $442,245, and $492,225. Engineer's estimate, $501,000.

LIST OF BIDDERS:

1. W. P. McCarren, Walhonding, Ohio (contract) $442,245
2. Ralph Myers Constr. Co., Salem, Ind 492,225

Item	Quan.	Unit Prices (1)	(2)	(3)*
1. Roadway excavation, unclass.	523,289 c. y.	$0.34	$0.42	$0.45
2. Unclass. structure excav.	85 c. y.	1.00	1.00	1.50
3. Channel excav. (to supply borrow)	3,100 c. y.	.40	.40	.60
4. Remove, dispose exist. conc. pavmt.	2,129.8 s. y.	.30	.20	.30
5. Remove, dispose conc. base and curb	3,260.9 s. y.	.30	.20	.32
6. Remove brick wearing crse. for reuse	22.2 s. y.	.30	.25	.40
7. Remove, store exist. brick pavmt.	21,074.8 s. y.	.25	.20	.20
8. Remove, dispose 6-in. sandstone base	1,541.7 s. y.	.10	.10	.03
9. Remove, dispose exist. 4-in. conc. sidewk.	500 s. f.	.02	.05	.02
10. Remove, dispose 6x18-in. conc. curb	21,446 l. f.	.02	.04	.08
11. Water (estimated)	2,497 M gal.	2.00	2.00	2.30
12. 12-in. corr. met. pipe, driveways	114 l. f.	1.25	1.20	1.35
13. 15-in. corr. met. pipe, driveways	100 l. f.	1.50	1.40	1.70
14. 12-in. rein. conc. pipe, storm sewers	46 l. f.	1.75	1.35	1.50
15. 12-in. paved bit. coat. c.m. pipe or paved invert corr. met. pipe, storm sewer outlets	205 l. f.	2.00	1.75	1.40
16. 8-in. helical perf. corr. met. pipe, rdwy. drain., full depth porous bkfill	1,236 l. f.	1.50	1.35	1.25
17. 6-in. ex. qual. drain tile, underdrains	1,530 l. f.	.50	.85	.90
18. 6-in. helical perf. corr. met. pipe, underdrains	1,000 l. f.	1.50	.80	1.15
19. 4-in. ex. qual. drain tile, underdrains	306 l. f.	.50	.75	.40
20. 6-in. corr. met. pipe, outlet for underdr.	20 l. f.	1.00	.80	1.15
21. 12-in., 20-deg. bend pipe specials	6 ea.	7.00	3.50	1.50
22. 6-in. wye pipe spec., underdrains	15 ea.	1.00	1.50	1.50
23. 6x4-in. wye pipe spec., full depth porous bkfill, rdway drainage	3 ea.	1.50	2.75	1.50
24. Class E conc., structures	95 c. y.	18.00	19.00	18.50
25. Drain basin, No. 1	1 ea.	100.00	50.00	60.00
26. Std. No. 3 catch basins	4 ea.	100.00	120.00	90.00
27. 18-in. type A riprap	36 s. y.	2.50	3.25	3.50
28. 4-in. conc. sidewalks (1 crse. constr.)	11,533.5 s. f.	.20	.20	.20
29. Paved gutter	1,056 l. f.	2.00	1.50	.85
30. Drain outlets	8 l. f.	1.00	1.50	1.20
31. Remove, store Type P-C guard rail	2,668 l. f.	.10	.20	.10
32. Aggregate, traffic bound side appr.	530.3 c. y.	1.50	3.00	2.00
33. Remove and dispose of 10-in. pipe	66 l. f.	.20	.20	.10
34. Remove and dispose of 12-in. pipe	830 l. f.	.20	.20	.12
35. Remove and dispose of 15-in. pipe	31 l. f.	.25	.20	.15
36. Remove and dispose of 18-in. pipe	64 l. f.	.25	.25	.15
37. Remove and dispose of 24-in. pipe	127 l. f.	.25	.30	.20
38. Remove existing structures	L.S.	300.00	200.00	250.00
39. Seed and protect rdwy. areas	127,000 s. y.	.04	.04	.04
40. Calcium chloride for traffic lanes	15 ton	30.00	30.00	25.00
41. Aggregate, traffic compacted lanes	3,200 c. y.	1.50	3.00	1.80
42. Std. str. flex. steel plate tens. type guard rail, or steel beam type guard rail	5,215 l. f.	.90	.95	1.05
43. Sodding	565 s. y.	.30	.20	.30
44. 7-in. rein. portland cem. conc. base crse.	13,533 s. y.	2.00	2.00	1.98
45. 9-7-7-9-in. rein. port. c. c. base crse.	30,539.2 s. y.	2.00	2.00	2.00
46. Bitum. impregnated paper insulation crse.	14,349 s. y.	.03	.02	.05
47. Completed mixture, del'd without chem.	205.3 ton	2.75	3.50	2.20
48. Spreading, shaping, compacting	616 s. y.	.15	.10	.20
49. Surf. trtmt. (seal coat) aggregate	2.3 ton	3.00	3.00	3.20
50. Surf. trtmt. (seal coat) bitum. mat'l	124 gal.	.25	.18	.18
51. Bituminous prime coat	155 gal.	.25	.18	.18
52. Surf. treatment bitum. material	321 gal.	.25	.18	.18
53. Surf. trtmt. cover aggregate, No. 46	10.7 ton.	3.00	3.00	3.10
54. 7-in. portland cement conc. pavement	67.3 s. y.	3.00	2.10	1.90
55. Port. cement conc. medina strip	42 s. y.	3.00	2.10	2.75
56. 9-7-7-9-in. rein. port. c. c. pavmt.	2,210 s. y.	2.00	2.10	2.15
57. 3-in. monolithic brick surf. crse.	44,072.2 s. y.	1.90	1.85	1.75
58. Salvage brick surf. crse. complete	222 s. y.	1.00	.90	.60
59. Type A concrete curb	5,080.2 l. f.	.07	.50	.65
60. Type 2 conc. curb and 2-ft. wide gutter	22 l. f.	2.00	1.50	.90
61. Type 4 conc. curb and gutter	360 l. f.	1.00	1.50	1.10
62. 9-in. rein. conc. approach slab	86.7 s. y.	6.50	3.50	4.20
63. Uncl. excavation, structures	1,074 c. y.	1.00	1.00	1.50
64. Channel excavation	1,082 c. y.	.75	.40	.60
65. Class C concrete	55.4 c. y.	20.00	19.00	17.25
66. Reinforcing steel	752 lb.	.05	.05	.06
67. 12-in. rein. conc. pipe, rdwy. culv.	278 l. f.	1.50	1.35	1.25
68. 15-in. rein. conc. pipe, rdwy. culv.	1,254 l. f.	1.75	1.60	1.60
69. 18-in. rein. conc. pipe, rdwy. culv.	676 l. f.	2.00	2.00	2.00
70. 24-in. rein. conc. pipe, rdwy. culv.	519 l. f.	2.75	3.00	3.00
71. 48-in. rein. conc. pipe, rdwy. culv.	268 l. f.	6.50	9.50	9.00
72. 24-in. 10-gage paved bit. coat. corr. met. pipe; or paved invert c.m. pipe	604 l. f.	6.00	4.75	3.50
73. 18-in., as above	256 l. f.	2.50	3.00	2.00
74. 12-in. rein. conc. pipe, rdwy. culv. outlet	71 l. f.	1.50	1.35	1.25
75. Standard No. 1–2 catch basins	15 ea.	50.00	50.00	40.00
76. Standard No. 1–3 catch basins	3 ea.	75.00	65.00	60.00
77. Standard No. 3 catch basins	3 ea.	125.00	60.00	90.00
78. Standard No. 3A catch basins	11 ea.	110.00	60.00	60.00
79. Standard No. 9A catch basins	9 ea.	125.00	90.00	100.00
80. Standard No. 1 manhole, modified	1 ea.	100.00	100.00	80.00
81. Type A grouted riprap	16.9 s. y.	2.50	3.00	2.50
82. 12-in. rein. conc. pipe, storm sewer	40 l. f.	1.50	1.35	1.50
83. 15-in. rein. conc. pipe, storm sewer	80 l. f.	1.75	1.65	2.00
84. 18-in. rein. conc. pipe, storm sewer	46 l. f.	2.25	2.40	2.50
85. 24-in. rein. conc. pipe, storm sewer	45 l. f.	3.75	3.50	3.50
86. 12-in. 20-deg. bend spec., rdwy. culv. outlet	4 ea.	7.00	3.50	2.00
87. Earth excavation, structures	202 c. y.	1.00	1.00	3.50
88. Class C conc., superstructure	96 c. y.	25.00	24.00	26.00
89. Class E conc., walls	162 c. y.	20.00	20.00	19.50
90. Class E conc., footings	37 c. y.	15.00	19.00	15.00
91. Type B waterproofing	28 s. y.	1.50	1.75	1.75
92. Reinforcing steel	25,520 lb.	.05	.05	.055
93. Structural steel	67,500 lb.	.06	.09	.065
94. Field painting of struct. steel	67,500 lb.	.003	.01	.003
95. Bridge railing (steel with conc. posts)	211.3 l. f.	5.00	2.00	7.00
96. First test pile (timber, incl. steel point)	L. S.	200.00	200.00	220.00
97. First test pile (10-in. H at 42 lb.)	L. S.	300.00	392.00	216.00
98. Standard timber piling	1,500 l. f.	.60	.70	.85
99. Steel pile points	44 ea.	1.25	.90	2.00
100. Steel piling (10-in. H at 42 lb.)	900 l. f.	1.50	2.00	2.30
101. Premium on industrial insurance	L. S.	5,000.00	3,000.00	6,354.69
102. Maintain traffic, etc	L. S.	3,000.00	7,000.00	4,000.00

** Engineer's estimate.*

HIGHWAY WIDENING, DELAWARE

OWNER: Delaware State Highway Department, Dover, Del.

PROJECT: Widening 3.289 miles of concrete highway from Blades to Concord, Del. Involves all necessary drainage structures, sidewalk, wood curbing, and patching of portion of existing concrete pavement.

CONDITIONS: Contractor to furnish all materials and complete work by December 1, 1941. Rail, highway and water transportation facilities available. Prevailing wages to be paid.

BIDS: Three bids were received June 4, 1941, ranging from the contract low of $60,113 to $67,871.

LIST OF BIDDERS:

1. Walter Roach & Sons, Georgetown, Del. (contract) $60,113
2. Old Line Constr. Co., Chestertown, Md 62,690
3. Waller Paving Co., Salisbury, Md 67,871

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clearing	2.7 ac.	$300.00	$400.00	$400.00
2. Grubbing	2.7 ac.	300.00	300.00	500.00
3. Unclassified excavation	11,000 c. y.	.50	.60	.75
4. Excavation for structures	120 c. y.	2.00	1.60	2.50
5. Borrow	1,500 c. y.	.30	.60	.65
6. Broken stone base course	30 ton	3.50	4.00	4.25
7. Cement concrete pavement	3,325 c. y.	11.00	11.14	11.50
8. ¾-in. std. dowel transverse expan. joints	950 l. f.	.80	.85	.90
9. Transverse contraction joints	1,200 l. f.	.40	.45	.50
10. Cement concrete masonry	125 c. y.	31.00	37.00	35.00
11. Reinforcing steel	8,600 lb.	.06	.07	.075
12. 12-in. rein. conc. pipe	150 l. f.	1.25	1.00	1.50
13. 15-in. rein. conc. pipe	435 l. f.	1.50	1.15	1.75
14. 18-in. rein. conc. pipe	171 l. f.	2.20	1.65	2.00
15. 24-in. rein. conc. pipe	15 l. f.	3.50	3.00	3.00
16. 8-in. corr. metal pipe	530 l. f.	1.00	1.00	1.25
17. 15-in. corr. metal pipe	60 l. f.	1.25	1.50	1.75
18. Timber piles	950 l. f.	.80	.90	1.25
19. Wood shoulder curb	3,650 l. f.	.16	.15	.20
20. Cement concrete sidewalk	4,000 s. f.	.28	.33	.30
21. Catch basins and drop inlets	3 ea.	30.00	25.00	50.00
22. Castings	1,500 l. f.	.08	.10	.08
23. 1-in. wire rope guard fence	2,960 l. f.	.90	.75	.80
24. End post attachments	24 ea.	10.00	7.00	10.00
25. Remove exist. conc. pavement	800 s. y.	.50	.35	.50
26. Patch present conc. pavement	360 s. y.	5.00	5.00	6.00
27. Std. dowel trans. exp. joints, patches	300 l. f.	1.00	1.05	1.10